Calhoun: The NPS Institutional Archive

DSpace Repository

Theses and Dissertations 1. Thesis and Dissertation Collection, all items

1998

Impact of incentives on project performance.

Mitchell, Jayson Doliber.

Monterey California. Naval Postgraduate School

http://hdl.handle.net/10945/8493

This publication is a work of the U.S. Government as defined in Title 17, United States Code, Section 101. Copyright protection is not available for this work in the United States.

Downloaded from NPS Archive: Calhoun

Calhoun is the Naval Postgraduate School's public access digital repository for research materials and institutional publications created by the NPS community. Calhoun is named for Professor of Mathematics Guy K. Calhoun, NPS's first appointed -- and published -- scholarly author.

Dudley Knox Library / Naval Postgraduate School
411 Dyer Road / 1 University Circle
Monterey, California USA 93943

http://www.nps.edu/library

NPS ARCHIVE
1998
MITCHELL, J.

DUDLEY KNOX LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY CA 93943-5101

Copyright

by

Jayson Doliber Mitchell

1998

Impact of Incentives

On

Project Performance

by

Jayson Doliber Mitchell, B.S.C.E.

Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Science in Engineering

The University of Texas at Austin

August, 1998

NPS Archive
1998
Mitchell, J.

~~T12553~~
~~M16855~~
~~c.1~~

DUDLEY KNOX LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY CA 93943-5101

Impact of Incentives

On

Project Performance

Dedication

This thesis is dedicated to my beautiful wife Catherine. She has been my number one supporter. Without her sacrifice, love, and support this thesis would not have been possible.

Acknowledgements

Special thanks to the Construction Industry Institute for their permission to utilize the project databases. Special thanks also to Dr. G. Edward Gibson for his wisdom and exceptional guidance during the preparation of this thesis.

August 1998

DUDLEY KNOX LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTEREY CA 93943-5101

Abstract

Impact of Incentives
On
Project Performance

Jayson Doliber Mitchell, M.S.E
The University of Texas at Austin, 1998

Supervisor: G. Edward Gibson

This thesis contains an in-depth research investigation into the types of construction contract incentives in both the public and private sectors. It utilizes data obtained from the Construction Industry Institute's (CII) Benchmarking and Metrics Program. The impact of safety, cost, and schedule incentives in this database is analyzed. The policy implications of the findings in this research are given for both public and private procurement agencies.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Aligning both owner and contractor objectives is widely thought to be a catalyst for better project performance. For this very reason, contract incentives are employed in order to identify and ensure focus on the owner's goals. The scope of this report is to research the extent of use and consequent effects of construction contract incentives offered by owners. The relative use by owners of construction phase incentives will be characterized, and an incentive use index assigned to each project. Additionally, the impacts of incentive use in terms of cost, schedule, and safety will be investigated. A relationship between the relative incentive use (incentive index) and project performance will also be examined.

This research will be accomplished using the Construction Industry Institutes' (CII) Benchmarking and Metrics version 1.0 and 2.0 database. This database includes responses from both owners and contractors. Since owners are the ones who will ultimately decide on the inclusion of any incentives, only their responses will be examined.

Reducing cost and schedule growth on a project is quite often a primary goal of an owner. This study will show how the use of cost and schedule incentives affects the cost growth and schedule growth of the construction phase

There are several objectives that this study aims to accomplish. This research should provide both the public and private owner with a foundation to aid them in their decision to use certain types of contract incentives.

Additionally, it is anticipated that private projects will have a higher relative incentive use index as opposed to public projects, and this research will attempt to show how the increased use of various incentives will affect project performance.

Positive incentives undoubtedly have a different impact on project performance as opposed to negative incentives (penalties, liquidated damages, etc.). The types of incentives employed by owners will be examined for their relative significance and impending results. Safety incentives will be studied to determine their impact on a project's "Recordable Incident Rate" (RIR) and "Lost Workday Case Incident Rate" (LWCIR), as defined by the Occupational and Health Administration (OSHA).

1.1 RESEARCH QUESTIONS.

There are several specific research questions that will be answered in this report. They are as follows:

- Does the use of positive safety incentives reduce a project's RIR and LWCIR?
- Does the use of positive (including combination positive/negative) cost incentives produce lower cost growth?
- Is the use of only negative schedule incentives (liquidated damages etc.) counterproductive to reducing schedule growth?
- Does the combined use of positive and negative schedule incentives reduce schedule growth?
- Does a higher incentive use index result in better project performance in terms of schedule and cost?

1.2 HYPOTHESES

For purposes of this study, the following hypotheses are offered using the null hypothesis approach:

- The use of positive safety incentives has no effect on a project's RIR or LWCIR;
- The use of positive (including combined positive/negative) cost incentives does not lower cost growth;
- The use of only negative schedule incentives has no effect on schedule growth;
- The combined use of positive and negative schedule incentives does not reduce schedule growth;
- A higher incentive use index does not result in better cost and schedule performance.

Chapter 2 of this report will include an extensive review of past literature and research concerning incentives. A brief discussion concerning the database utilized, as well as the analysis procedures, will follow in Chapter 3. Chapter 4 presents the analysis of each of the hypotheses and also includes a characterization of the data received from each of the respondents. Last, conclusions and recommendations on the use of contract incentives will be presented in Chapter 5. This thesis should aid both public and private entities with their procurement strategies.

Chapter 2: Background

2.1 Benchmarking and Metrics at CII

The Construction Industry Institute (CII) is an organization of owners and contractors based administratively at the University of Texas at Austin. CII is primarily a research organization whose mission is:

> "...to improve the safety, quality, schedule, and cost effectiveness of the capital investment process through research and implementation support for the purpose of providing a competitive advantage to North American business in the global marketplace." (Hudson 1997).

The CII Board of Advisors established a Benchmarking and Metrics Committee in 1993, whose objectives were to establish a series of metrics that could be applied to all sectors of the construction industry and identify "best practices" that could be used to positively influence the metrics being measured.

All of the data utilized for analysis in this thesis were obtained from CII's Benchmarking and Metrics (BM&M) database. The CII BM&M committee has identified three objectives. They are as follows:

- To provide "the industry" (defined broadly as heavy industrial, light industrial, buildings, and infrastructure) with "norms";
- To measure the use of "best practices" and quantify the value of implementing CII recommended practices;
- To help educate the industry in benchmarking practices and interpretation of data for improvement within their respective companies (CII BM&M Report 1997).

A primary difference between CII's benchmarking approach and benchmarking services offered by other organizations is the level of analysis and feedback provided to individual companies. CII seeks to provide companies with tools to allow in-house analysis of project performance, rather than provide extensive individual project analysis. Individual companies will thus be in a better position to improve. The tools include: a set of well defined performance metrics, a report of industry "norms" for comparison purposes, and reports of general analysis which identify practices that correlate with successful project performance.

2.2 Contract Incentives

The following literature review has been completed in order to provide the author of this report with a strong foundation of knowledge on the purpose and use of construction contract incentives. There was a large sample of literature available for review, probably due to the fact that owners and contractors are now, more than ever, trying to streamline their goals so as to derive mutual benefits. This review will be broken down into several categories that ultimately relate to the research questions already mentioned.

The purpose of contract incentives will be discussed first, followed by a discussion on owner and contractor goals and objectives for construction projects. Risk allocation and motivational theory will then be discussed, followed by a brief comparison of incentive contracting with Total Quality Management (TQM)

principles. Owner and contractor goals, risk allocation, and motivational theory are the main factors in the success or failure of any incentive plan. These topics are invaluable to the comprehension of incentive contracting. The remainder of the literature review will focus on the different types of incentives available to owners, as well as the advantages and disadvantages of their use.

The word “incentive” is derived from a Latin word meaning, “to stimulate”, and when incentives are properly employed, they can stimulate contractors to support, and perhaps even adopt, the goals and objectives of the owner (Neil 1990). Stukhart points out that contract incentives “are the means by which an owner intends to secure certain project goals through the contracting process” (Stukhart 1984). Put more simply, they encourage the contractor to adopt the owners project objectives, essentially making them mutual objectives. By doing so, both the owner and contractor will ideally maximize their respective benefits, assuming a proper incentive plan is developed. Since one of the main motivators for a contractor is often profit, money awards are the most frequently employed incentives.

So what are project goals? They may be an assortment of many things. The main goals that incentives support are reduced cost, reduced project duration (schedule), increased safety performance, and better quality. The aforementioned goals are usually adopted by both the owner and contractor, albeit each usually occupying a different priority. Neil points out that owners are finding that

incentives are a valuable tool in supporting other goals such as the improvement of day-to-day management of work, maintaining favorable labor relations, assuring commitment of the best personnel by the contractor, and improving owner/contractor communication and cooperation (Neil 1990). Admittedly, by effectively motivating a contractor to focus on goals such as reduced cost, reduced schedule growth, and reduced accidents, these “indirect” goals are likely to follow suit.

The Construction Industry Institute reported in 1995 that incentives improve performance in the following ways:

- They drive the definition of the project;
- They align project participants on common objectives;
- They create an interdependence among project participants;
- They establish a mutually supportive environment;
- They open communication channels and enhance team building;
- They reward desired behavior.

Again, by establishing incentives for project performance, the above goals are more likely to be realized.

Before continuing, it is important to point out “what contract incentives are not.” They are not payment for risk assumption. The contractor should not receive a bonus for the random occurrence of events beyond its control (Ashley 1986). Incentives are paid when a contractor meets or exceeds previously identified standards of performance, of which they have direct control.

As previously mentioned, the purpose of contract incentives is to bring the objectives of the contractor in line with those of the owner. These objectives need to be communicated effectively to the contractor if the desired results are to be realized. Unless the objectives are clearly understood by both parties, they will not be effective (Stukhart 1984). Generally speaking, the owner of a project will usually have three accepted goals: most economical cost, specified quality, and on-time completion (Stukhart 1984). The contractor will typically maintain the obvious goal of maximizing his or her their profit. Other goals and objectives do exist, and these will be discussed in the upcoming paragraphs.

Both owners and contractors must realize that risk is a principle that must be shared, and contractors must be able to control the resources necessary to achieve the incentives. Risk should be commensurate with potential gains. Stukhart (1984) defines risk as the exposure to possible economic loss or gain. He further states that risk allocation is very important in order for incentives to be effective. Risk is allocated to contracting parties in order to motivate them to perform in a professional manner. It is based in part on the return of profit to be realized. As previously mentioned, the degree of control over the risk must be considered. Responsibility for an end result must entail complete control over its occurrence. Finally, the relative "ability" of the parties to protect themselves against the risk is also a major consideration (Stukhart 1984).

Ashley and Workman (1986) developed some factors to consider in determining the optimum allocation of risk. They include:

- The perception of risk;
- The controllability of risk (accountability without control costs money);
- Preference for risk assumption (ability to absorb or insure against it);
- The opportunity of risk (incentive value of risk)

Ibbs and Abu-Hijleh (1988) state that "excessive risk" offers no incentive value. They further state that it is in the owners best interest not to pass on all risks to the contractor; otherwise adversarial relationships will develop which counteract the goals of the incentive process. In summary, performance can be encouraged by the simple allocation of reasonable risk.

Since incentives are enacted to help "motivate" a contractor, the next few paragraphs will discuss motivational theory. Degoff and Freeman (1985) write that motivation is best defined in terms of its behavioral operations and that it is foremost, "goal oriented." It incites and directs an individual's action to accomplish a task. Ashley and Workman (1986) state that motivation is "a drive to satisfy a need or desire through goal attainment." Furthermore, the needs and desires of any contractor can be reduced to profit maximization. This goal constitutes a self-motivation in construction contracting. Effective motivation in contracting requires the adoption, at least indirectly, of the owner's project objectives by the contractor. This is the role of incentives: to motivate.

Stukhart (1984) feels that in a fixed-price contract, "the contractor achieves a major motivational factor, the desire to be in control of one's fate, ..."

The problem with most fixed-price contracts is that most are written without the involvement of the contractor, and adhesive terms often dictated to the contractor. Although the contractor is still in control of its destiny, other important success factors may be absent (communications, non-adversarial relationships, shared goals and objectives, etc.). Incentives help to derive the benefits of these other success factors.

The aforementioned principles are, at least in part, consistent with the goals of the Total Quality Management (TQM) process. The Transit Cooperative Research Program Report 8 stated that TQM change is about how organizations "perform work, get better at what they do, ...and inspire and reward their people" (TCRP Report 8, 1995). Just as the TQM process moves from the traditional, outdated mode of operation, to a newer, more progressive way of operation, one which improves and evolves continuously, so does the ideal incentive process. The TQM roadmap included in Report 8 identifies three distinct phases: Foundation, Momentum, and Commitment. These three phases are attributable to an effective incentive process as well. The Foundation phase forms the team, discusses shared goals and objectives, clarifies other values and expectations, and identifies satisfaction criteria. The Momentum phase further clarifies expectations, as well as recognizes and rewards desired behavior. The Commitment phase implements the management systems, establishes processes, and evaluates and improves through an appraisal system (TCRP Report 8 1995). Certainly the TQM process is substantially more involved than a simple contract incentive, however it can be safely said that the incentive process seeks the same

end result as the TQM process, and accomplishes those goals in much the same manner.

There are a multitude of types of incentives available to owners. Depending upon the desired outcome of a project, the proper incentive(s) can be selected. Positive incentives reward a contractor for desired results, whereas negative incentives attempt to dissuade poor performance in specific areas by decreasing the amount of a contractor's fee. Incentives can be based on safety, cost, schedule, quality, and they exist in other fashions which will soon be discussed.

Most would agree that the best contractual incentive programs have a "win" feature. Those with only a "lose" potential are generally frowned upon (Neil 1990). A "win" feature is essentially a positive incentive, and a "lose" feature a negative incentive. A positive incentive focuses on the desired outcome, and rewards this desired outcome in a positive way, usually in the form of a monetary award. Positive incentives encourage positive contractor actions, behaviors, and relationships, as opposed to negative incentives (liquidated damages, which assess a penalty for late completion, are considered a negative incentive) (Neil 1990). Ashley and Workman (1986) point out that research has demonstrated that positive incentives contribute to improved project results, while negative incentives generally hamper project performance.

A combination of positive and negative incentives may be the solution for owners who are a skeptical of a "positive" only approach. Bechtel Group has used combined positive/negative incentives to avoid sub-optimized project

performance with great success. Combined incentives and cost sharing generally keep the contractor in good alignment with the customer's objectives and can be combined with schedule, safety,...and output performance incentives to match and balance contractor incentives with customer objectives (CII, 1995). This report further states that combined incentives, although difficult to administer, have proven fairly successful. Thus an educated, knowledgeable owner with the requisite resources could benefit from the use of combined incentives.

The following is a list of positive and negative incentives that have been utilized in the past:

Positive Incentives

- Awards for low or zero RIR/LWCIR (see Chapter 3 for definition);
- Awards for completion of construction under budget or under a guaranteed maximum price (GMP);
- Bonuses for meeting or exceeding target completion dates and milestone dates;
- Report card bonuses which take into account a contractor's overall performance over a designated period;
- The possibility of being selected by the owner as a long-term partner, or establishing a strategic alliance;
- The "Golden Letter"-a letter of commendation written by the owner for a job well done. This gives the contractor something of considerable market value;
- Preference on additional, future work

Negative Incentives

- Liquidated damages for late completion of an established milestone or overall completion date;
- Cost sharing or reduced fee for exceeding a construction budget (applicable in cost reimbursable type contracts);

- Increased retainage for undesirable performance (Neil 1990).

When an owner is a government contracting agency, it is usually required to accept low bids, and has difficulty employing most of the non-monetary incentives discussed (with the exception of the "Golden Letter").

2.3 Keys to Incentive Use Success

For all the above incentive plans to work, it is crucial that the criteria be identified and agreed upon well in advance. Negotiated targets result in greater ownership and commitment by the contractor (Ibbs and Abu-Hijleh 1989). In addition, a cooperative relationship between the parties is considered instrumental in reducing project uncertainty and increasing the chances for project success (CII Pub. 24-1). Furthermore, owner personnel must genuinely want the contractor to achieve the maximum incentive because it corresponds to maximum owner success (CII Conference Packet 1996). Jaraiedi, Plummer, and Aber (1995) state that it is important for the contracting agency or owner to do everything possible to eliminate delays and disruptions. This essentially means that extra time and effort must be given to project development so as to avoid costly changes once the project begins. These changes not only affect the cost, but may impact the completion of a milestone or the entire construction process. If changes are made deadlines and targets should be adjusted so the contractor does not suffer a reduced award for circumstances that are the fault of the owner.

Even with all of the possible advantages of using incentives, there are some disadvantages as well. Positive incentives require substantially more contract administration. Ashley and Workman state that contracts with positive incentives appear to have stricter enforcement, greater disputes, and more suggested improvement than contracts without positive incentives (with the exception of positive cost incentives) (Ashley and Workman 1986). There is a tendency for owners to induce the contractor to accept more risk with incentives, which, as stated earlier, is not the purpose of incentives. Ashley and Workman (1986) identified some of the major disadvantages of incentives, as seen by the Business Roundtable:

- Owner's difficulty in establishing fair and equitable targets;
- Owner's additional administrative costs;
- Extra negotiations needed for implementation;
- Changes in owner priorities, beyond the contractor's control, require adjustment and possible re-negotiation of targets.

These disadvantages can be overcome with the proper awareness and management. It is possible to derive the positive benefits from incentive use, and CII (1995) has provided the following lessons learned and recommendations for incentive use:

- Align project incentives with key business success opportunities;
- Make incentives measurable and objective, using relevant benchmarks;
- Include (and preserve) incentive funding at expected outcome levels;
- Frequently share expectations and results;
- Link incentives to outcomes that reasonably can be controlled;
- Incentives alone do not ensure project success.

Chapter 3: Research Methodology

All of the data used to analyze incentive use was obtained from the Construction Industry Institute (CII). The data includes accumulated data, otherwise known as the Benchmarking and Metrics (BM&M) Database collected over a two-year period from 1996 through 1997. This database consists of 393 owner and contractor projects totaling over $20.6 billion in cost. Most of the projects are classified as "Heavy Industrial" and are located in the United States and Canada (CII BM&M Report 1997). Since the purpose of this thesis is to determine whether or not construction contract incentives can help owners or procurement agencies reach their goals, only the owner data were analyzed.

Most of the resources utilized for the literature review were found in the Engineering Library at the University of Texas at Austin. A few items were borrowed or purchased from CII, where a significant amount of literature concerning construction is available. There was ample material to conduct a comprehensive literature review.

The BM&M database includes two years of accumulated data. The files for each year are maintained separately, thus a significant amount of time was spent simply stratifying the data from the 1996 files (Version 1.0), and the 1997 files (Version 2.0). The incentive use information for each respective project was included in a separate file from that of the general project information and much time was spent transferring the appropriate incentive information to the file containing the general project information. This incentive information referred to

was simply each owners' reply concerning the use of cost, schedule, and safety incentives, as well as the type used (positive, negative, or both) if any. Figures 3.2 and 3.3 at the end of this chapter show how each incentive question was prepared in Version 1.0 and 2.0 respectively. Figure 3.1 is an easy reference flow chart showing the complete methodology used for completion of this thesis.

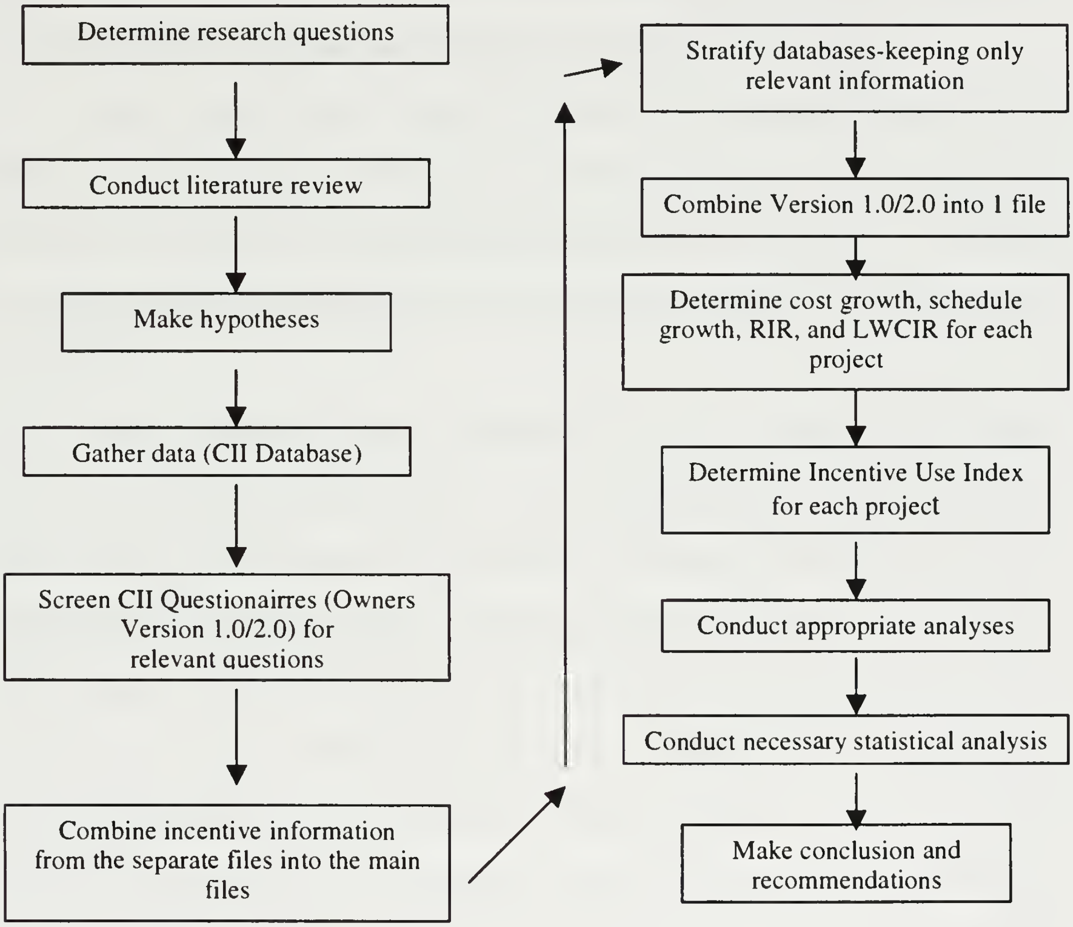

Figure 3.1: Research methodology flowchart

Once the appropriate incentive information was included with each file, both versions of data were screened and all of the data unrelated to this research was deleted so as to provide for a more streamlined, easy to manipulate, file. The major information that was kept (refer to Appendix B) included the project number, public or private contract, incentives used, construction budget, construction cost, planned schedule, as-built schedule, as well as the number of recordable and lost workday case incidents for each respective project.

Finally, both versions 1.0 and 2.0 needed to be combined into one file in order to conduct the appropriate analysis. Each column of data had to contain the exact type of information as that particular column from the other file. After both versions of data were combined into one master spreadsheet, the data were ready for analysis.

The spreadsheet program used for this entire process (and for graph development) was Microsoft Excel™. This program made for simple sorting of data. Each time an analysis was made using a different dependent variable, the appropriate sort function could be carried out from the master file. For example, when analyzing safety performance versus safety incentive use, the database was sorted by the column containing the incentive type used (if any), with the RIR and LWCIR subsequently being calculated. Projects lacking the necessary data to evaluate safety performance were simply deleted from that particular analysis (a project that gave no information on the lost workday cases may still be valuable when evaluating cost growth).

Below are the formulas used during the analysis portion of this research. With the exception of the incentive use index, all formulas are in the same format used by the CII benchmarking committee.

- Safety Performance:

  1. Recordable Incident Rate (RIR):
  (# recordable incidents)/(# craft work hours) * (200 K w-h/yr).

  2. Lost Workday Case Incident Rate (LWCIR):
  (# lost workday cases)/(# craft work hours) * (200 K w-h/yr).

- Construction Cost Growth:
  (Actual Construction Cost-Budgeted Construction Cost)/Actual Cost.

- Construction Schedule Growth:
  (Actual Construction Duration-Predicted Duration)/Predicted Duration

- Incentive Use Index:
  The total number of incentives used on a project. The range is between 0 and 6, and accounts for safety, cost, and schedule incentives only. For example, if a project employs both positive and negative schedule incentives, the corresponding incentive use index would be 2.

Hypothesis testing was performed using statistical analysis. This analysis essentially compares the relative values of two means to determine if the difference between them, if any, is significant or can be attributed to chance. Using either the z or t statistic, an analysis can be made. For analysis containing 30 or more projects in the sample, the z statistic is used. For analysis containing less than 30 samples, the t statistic is used (Blank, 1980). All the analyses (except for the one concerning the evaluation of negative-only schedule incentives where the t statistic is used) used the z-statistic since each analysis sub-sample contained more than 30 projects.

The objective of these tests is to determine whether the means of two samples of projects are equal to each other at a certain level of significance. By establishing the null hypothesis [Mean of sample 1 = Mean of sample 2:($\mu_1=\mu_2$)], one can prove if the two samples are considered equal or not. Unless the null hypothesis is accepted, the means are not considered equal. If the null hypothesis is accepted, one can conclude that any difference in the two populations is attributable to chance or sampling error, and not due to whether or not incentives were used. The level of significance used to prove or disprove the Null hypothesis in this thesis is 95%. The z-values are also compared to the acceptance range at 90% confidence, as well as other values if it could be shown to be significant. The formulas used for calculation of the z-value are as follows:

$\sigma_d=((\sigma_1)^2/N_1 + (\sigma_2)^2/N_2)^{.5}$

(σ=standard deviation, N = number of projects in sample)

$z=(\mu_1-\mu_{-2})/ \sigma_d$.

(μ=mean)

The Null hypothesis acceptance ranges at various levels of confidence are shown below:

95%: z-value from -1.96 to 1.96

90%: z-value from -1.645 to 1.645

86.7%: z-value from -1.5 to 1.5

80%: z-value from -1.282 to 1.282

The analysis of the data follows in Chapter 4 and reflects the aforementioned methodology.

11. Contract Incentives (for each phase and incentive category check whether contracts included positive, negative, or no incentives. A cash award for meeting a milestone is an example of a positive incentive, and liquidated damages for failing to meet a milestone is an example of a negative incentive. List other incentivized objectives in the blanks provided. If your company solely performed the duties required in a phase, leave blank)

	Pre-project planning			Design			Procurement			Construct			Start-up		
	+	-	0	+	-	0	+	-	0	+	-	0	+	-	O
Cost															
Schedule															
Safety															
Productivity															
Quality															
Customer Satisfaction															
Operability															

Figure 3.2: Version 1.0 Incentive use question

(Version 2.0: Question 10)

If **Contract Incentives** were utilized, please indicate whether those incentives were positive (a financial incentive for attaining an objective), negative (a financial disincentive for failure to achieve an objective), or both. Circle "+" to indicate a positive incentive and circle "-" to indicate a negative incentive.

Comp. Name	Func -tion	Approx. Percent of Function (Nearest 10%)	Type of Remun. (Contract End)	Was this comp. an alliance partner ? Yes/No		Contract Incentives (circle as many as apply)							
						Cost		Schedule		Safety		Quality	
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-

Figure 3.3: Version 2.0 Incentive use question

Chapter 4: Analysis

4.1 Sample Characterization

This analysis was conducted on 183 owner-submitted projects. None of the data submitted to CII by any contractor was considered. Before any hypothesis testing was done, the sample was first broken down several different ways in order to characterize the diversity of projects. All of the descriptions provided are presented in both graphical and written format throughout the chapter.

Figure 4.1 shows the sample projects in terms of "Industry Type." Any project submitted to CII is included in one of four possible categories. The categories are building projects, heavy industrial projects, light industrial projects, and infrastructure projects. Examples of each type are as follows:

- Heavy Industrial Projects-Electrical Generating, Oil Exploration & Production, Oil Refining, Pulp and Paper, Chemical Manufacturing, Environmental, Metals Refining & Processing, and Natural Gas Processing;
- Light Industrial Projects-Pharmaceuticals Manufacturing, Consumer Products Manufacturing, Microelectronics Manufacturing, Automotive Manufacturing, Foods, and Office Products;

- Infrastructure Projects-Electrical Distribution, Highway, Navigation, Flood Control, Rail, Water/Wastewater, Airport, Tunneling, Marine Facilities, and Mining;
- Buildings-Lowrise/Highrise Office, Warehouse, Hospital, Laboratory, School, Prison, Hotel, Maintenance Facilities, Parking Garage, and Retail.

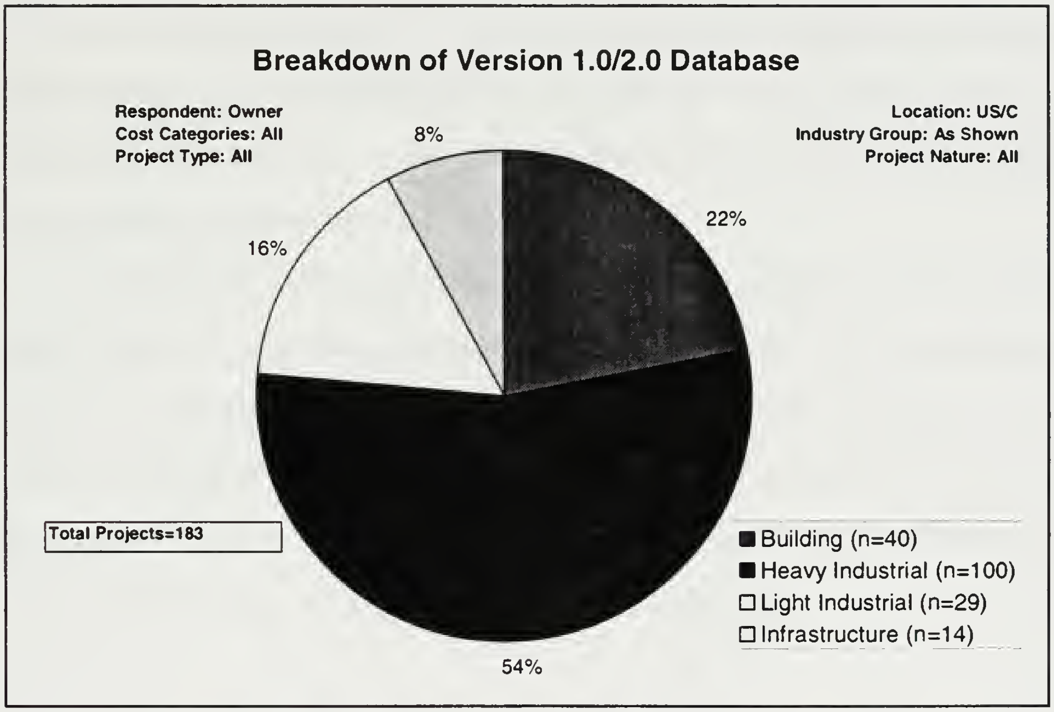

Figure 4.1: Breakdown of database by industry type

As can be seen in Figure 4.1, the majority of the projects are heavy industrial. A total of 100 projects, constituting 54 percent of the database, were heavy industrial. The next largest group was the building projects, which numbered 40 in all (22 percent). The remaining sample projects included 29 light

industrial projects (16 percent) and 14 infrastructure projects (8 percent). As noted in the figure, these projects were from all cost categories.

The types of projects submitted were further classified as being modernization, grass roots, or add-on projects. Modernization projects are facilities for which a substantial amount of the equipment, structure, or other components are replaced or modified, and which may expand capacity and/or improve the process or facility. Grass roots projects are where a new facility is built from the foundation and up. A project requiring demolition of an existing facility before new construction begins is also classified as grass roots. Add-on or addition projects are those where a new addition ties in to an existing facility, often intended to expand capacity.

The projects were essentially evenly distributed among the three project types. Figure 4.2 shows this distribution. A total of 65 projects were classified as grass roots (36 percent), while the remaining 118 projects were split evenly between modernization and addition projects (32 percent each). This even distribution of projects is probably less significant than the uneven distribution in terms of industry type, given the wide range of cost and scope.

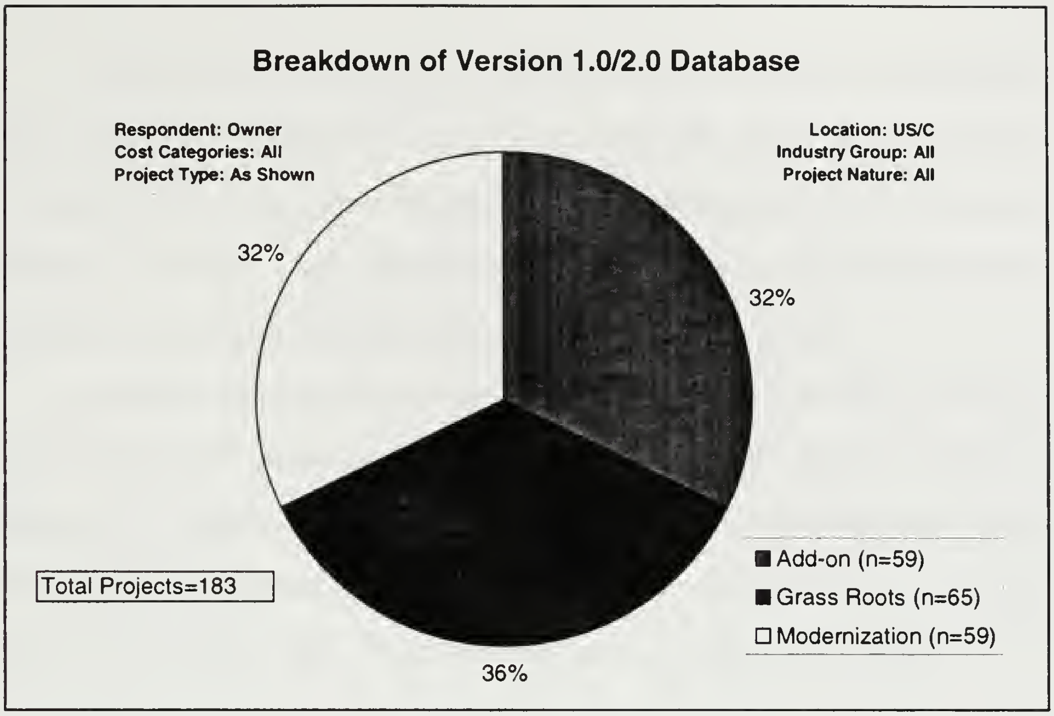

Figure 4.2: Breakdown of database by project type

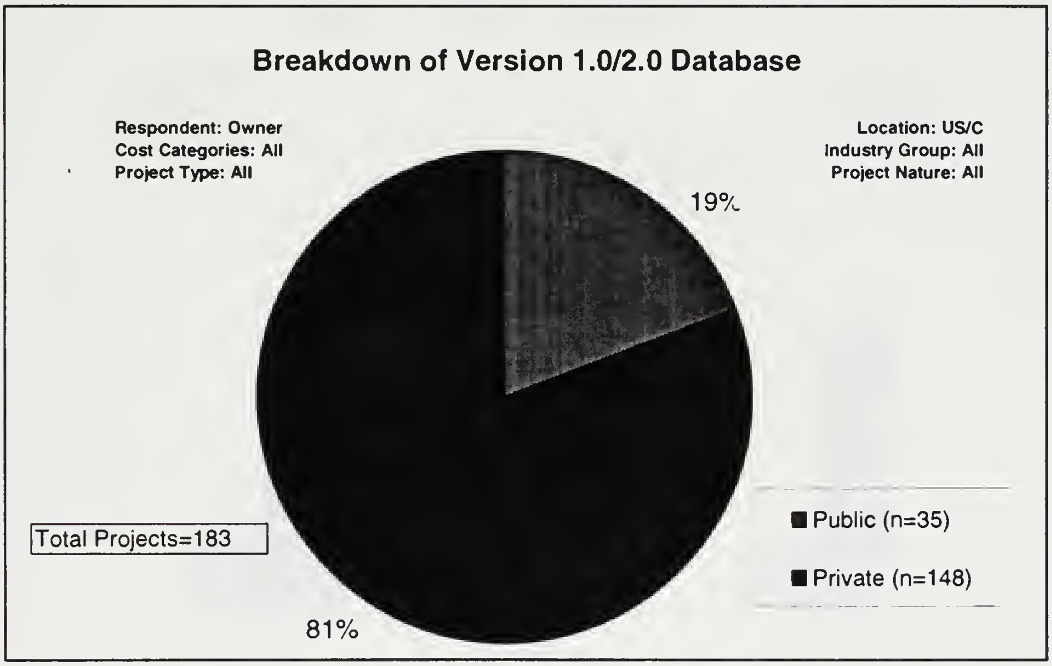

Figure 4.3: Number of public and private projects in database

The database was dominated by private projects, as shown on the previous page in Figure 4.3. A total of 81 percent, 143 out of the 183 projects, were from the private sector. The portion of public projects represented a mere 19 percent, 35 in all, of the data. Although this is unbalanced, there is still enough data to provide some significant comparisons between the two populations.

Public and private entities were each evaluated based on their respective incentive use. Each group was looked at individually and the amount of projects utilizing cost, schedule, and safety incentives (all types) was determined. Figure 4.4 and Figure 4.5 illustrate the public and private use of incentives. Some projects had multiple incentives and are reported in more than one category.

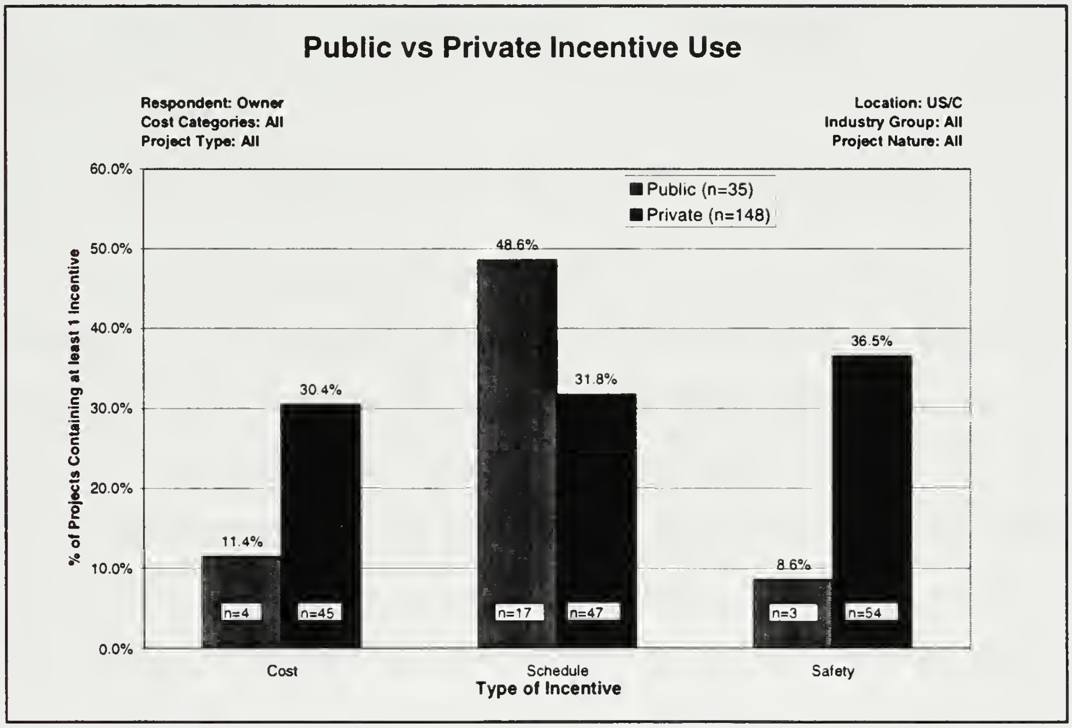

Figure 4.4: Public vs. private entity incentive use

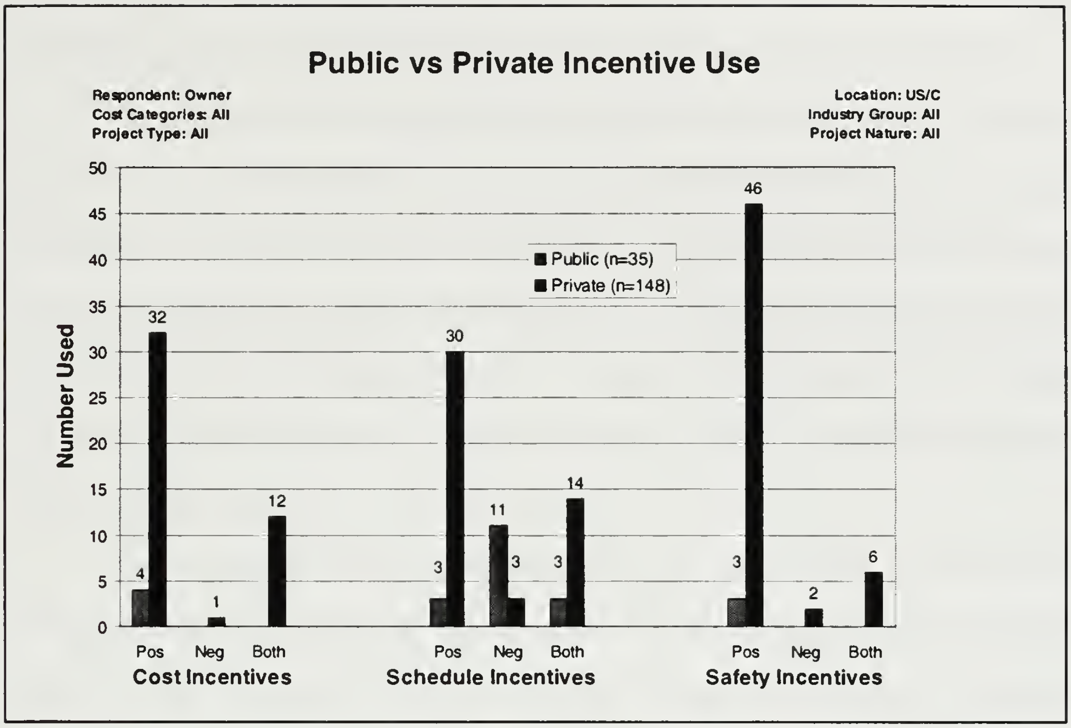

Figure 4.5: Types of incentives used by public and private entities

As was anticipated, private entities used cost incentives a great deal more than public. In fact, they employed them almost three times as much. The private sector reported a 30 percent use rate, while the public reported just over 11 percent. Since most public entities are constrained by narrow procurement statutes, which mandate the acceptance of the lowest responsible, responsive bidder, this is not surprising. As Figure 4.5 shows however, there were four public projects that reported the use of positive cost incentives. All four of these projects were classified as electrical additions (modernization projects). It is

interesting to note that three of these four projects were procured on a cost-reimbursable basis, which lends itself perfectly to the use of cost incentive use.

It is quite obvious why the private sector uses cost incentives. They are attempting to control expenditures so that the maximum return on investment may be realized. Private entities are in business to make profit, and by sharing any cost savings with the contractor, they feel they may be increasing their chances of realizing this goal. As Figure 4.4 shows, a total of 45 private projects included cost incentives (30.4 percent). Of these 45 projects, only one utilized a negative-only incentive approach.

The calculated use of schedule incentives, also shown in Figure 4.4, provided interesting results. Of the 35 public projects, 17 employed some type of schedule incentive, almost 50 percent. Figure 4.5 shows that, of these 17 projects, 11 utilized negative-only incentives (most likely the assessment of liquidated damages for late completion). Three projects reported the use of positive-only incentives, and the remaining three public projects used a combination of positive and negative schedule incentives.

The private use of schedule incentives was similar to their use of cost incentives. There were 47 private projects that contained some type of schedule incentive, which amounted to just under 32 percent (see Figure 4.4). In contrast again with public entities, Figure 4.5 shows that 30 of these 47 projects utilized positive schedule incentives. Only three of the 148 private projects utilized a negative-only schedule incentive. A total of 14 projects included both positive and negative schedule incentives. This thesis will attempt to show that the use of

negative-only schedule incentives is counterproductive. Private owners seem to have adopted the same theory by looking at their overall schedule incentive use.

The comparative use of safety incentives was similar to that of cost incentives and is also included in Figures 4.4 and 4.5. Only three of the public projects utilized a safety incentive, a total of only 8.6 percent. A significant number of private entities did, however, use safety incentives. A total of 54 out of the 148 private projects (36.5 percent) employed them. Figure 4.5 indicates the types of safety incentives utilized were essentially all positive, although two private projects reported the use of negative-only safety incentives, and six private projects employed a combination of positive and negative incentives.

As is the case with cost incentives, it is likely difficult for public owners to justify the use of safety incentives. Under constant scrutiny from the general public, incentive use is a "hard sell." Private firms are free to employ any kind of incentive that they wish in order to help them realize their goals. Reducing the number of accidents on a private project is probably a higher priority due to the litigious atmosphere that has recently developed. Third party lawsuits are more likely to be filed against a private entity than a public one. Most public contracts contain a significant amount of exculpatory language that indemnifies them anyway. CII has estimated that a Recordable Incident (RI) costs approximately $1100, and a Lost Workday Case (LWC) costs almost $50,000. If safety incentives can be shown to reduce the RIR and LWCIR on a project, not only will significant money be saved by all parties involved in the construction process, the

intangible effects of a safer jobsite like better moral, higher productivity and better efficiency will abound.

The next comparison made was the relative incentive use among the respective industry types, shown in Figure 4.6. The largest representative group, heavy industrial projects, also recorded the most incentive use among the industry types. Of the 100 heavy industrial projects, 37 (37 percent) employed some type of cost incentive, almost double the percentage of all the other industry types. Schedule incentive use was slightly higher at 40 percent, and an even higher number of heavy industrial projects, 44 percent, utilized safety incentives.

At the low end, except for schedule incentive use, was the building industry. Only four of these projects (10 percent) utilized a cost incentive, and an even lower number, 7.5 percent, employed safety incentives. It would be interesting to see the overall RIR's and LWCIR's for each industry type to determine if one is considered safer than the rest. The incentive use rates indicated in Figure 4.6 are not assumed to be representative of the construction industry as a whole. Building projects did record the second highest schedule incentive use at 35 percent.

The light industrial and infrastructure projects were similar in their use rates. Cost incentives were employed 14.3 percent and 20.7 percent of the time respectively. Schedule incentives were seen on 21.4 percent of light industrial projects, and on 24.1 percent of the infrastructure projects. Safety incentive use was slightly over 20 percent at 21.4 percent and 24 percent respectively.

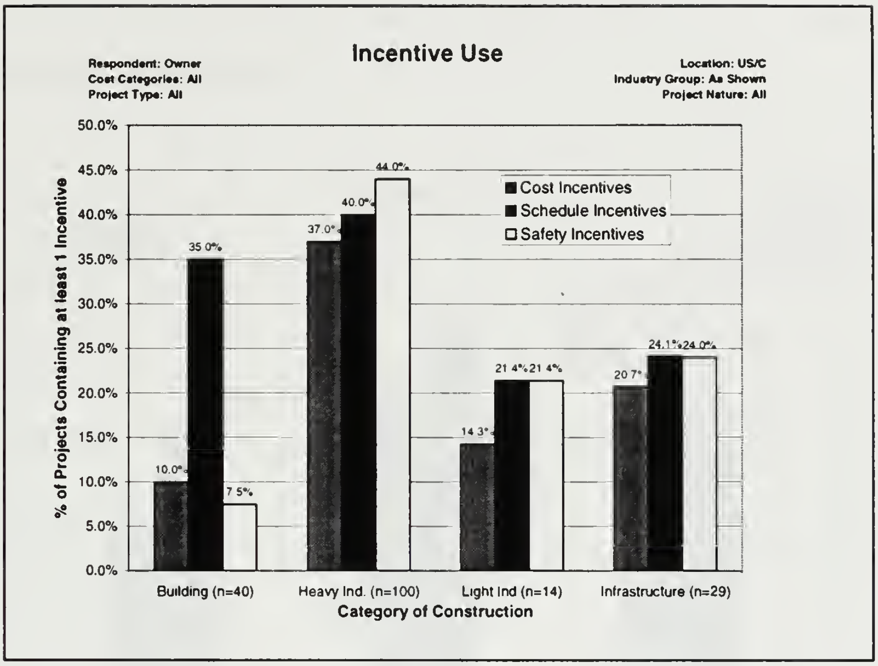

Figure 4.6: Incentive use within each industry type

Incentive use was also characterized in terms of project nature. Figure 4.7 shows how the 183 projects utilized incentives from the perspective of project type. Grass roots projects indicated the highest overall incentive use. Of the 65 grass roots projects, 22 utilized some type of cost incentive (33.8 percent), with over 40 percent containing a schedule incentive (27 total). Addition and modernization projects had similar use rates. Of the 59 addition and modernization projects, 22 percent and 23.7 percent employed cost incentives respectively, approximately 10 percent below that of grass roots. Schedule incentive use in these two categories was also approximately 10 percent below that of the grass roots projects. Addition projects utilized them 30.5 percent of the

time, while modernization projects employed them slightly more at 32.2 percent of the time. All three categories reported safety incentive use at slightly over 30%, a fairly even distribution.

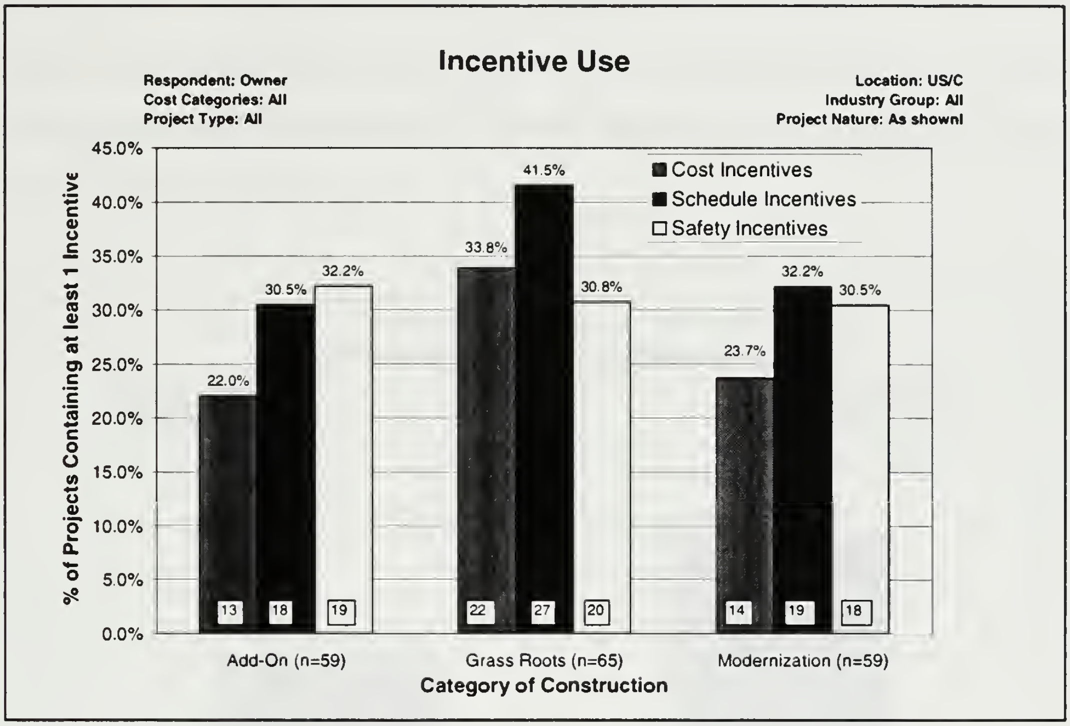

Figure 4.7: Incentive among each construction category

Given that most of the projects are of the heavy industrial type, it is not surprising that the grass roots projects contain more schedule incentives than the rest, since a quicker completion of the new facility may result in a quicker return on investment.

The final comparison for characterization purposes is provided in Figure 4.8. This graph shows the average Incentive Use Index for both public and private entities. As was shown in the previous paragraphs, private projects

generally contain a higher percentage of incentives when compared to public projects. The possible score for the Incentive Use Index is in the range of 0-6. Private projects had an average index rating of 1.2, 33 percent higher than the public projects' average rating of 0.8. This seems to be consistent with logical thought. Later, this report will attempt to correlate a higher incentive use index with improved project performance. The development of the incentive use index was discussed in chapter 3.

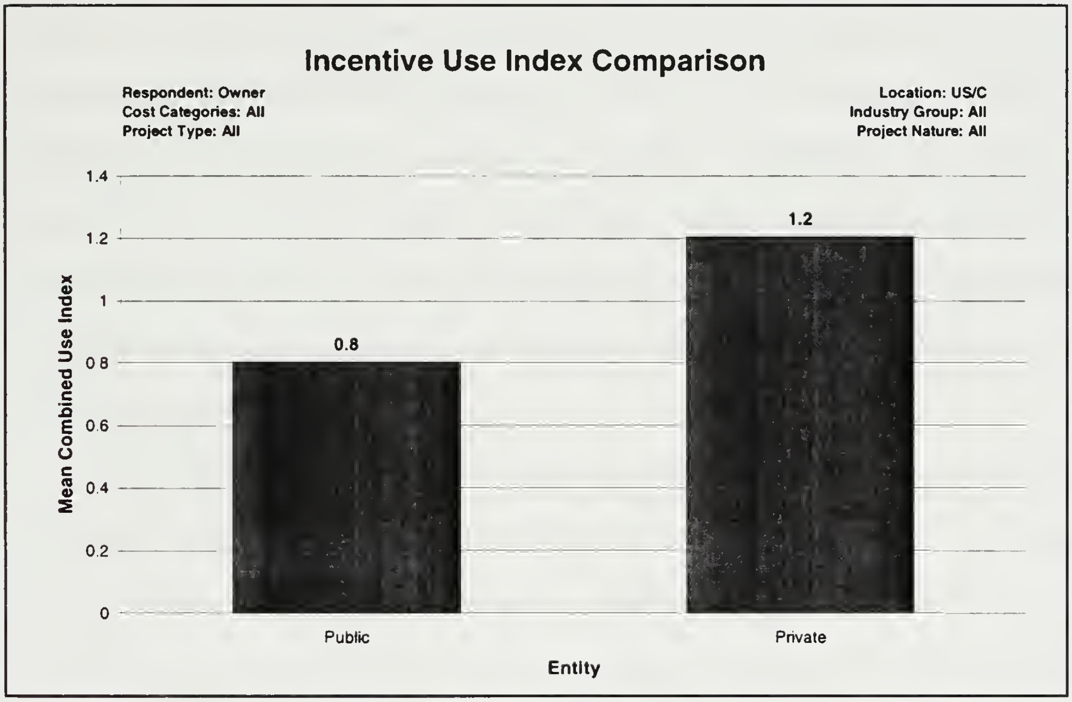

Figure 4.8: Average Incentive Use Index for public and private entities

4.2 Safety Performance vs. Safety Incentives

Safety incentives are utilized on construction projects for the obvious reason of curbing accidents. The construction process is inherently dangerous, and given the escalating cost of insurance, reducing the amount of incidents makes sense. The costs of accidents, already mentioned in this thesis provide ample reason to endeavor to reduce the accident rate on a project.

Safety incentives are employed by owners with the expectation that a contractor will take extra time in the proper planning and execution of each activity. It is also hoped that each individual construction worker will have an increased awareness concerning safety on the job site. The average RIR and LWCIR for the construction industry, as reported by OSHA, is 9.8 and 4.3 respectively. As one can discern from Figure 4.9, the average rates from the owner projects are very low compared to the industry as a whole. CII reports that CII member companies maintain an impressive average RIR and LWCIR of 2.3 and 0.48 respectively.

The owner projects were analyzed to determine if the use of positive safety incentives had any impact on the RIR and LWCIR of a project. To test the null hypothesis, which says that there is no difference (whether or not incentives were used), the projects were separated into those that employed positive safety incentives and those projects that did not indicate the use of any safety incentives at all. As discussed in Chapter 3 of this report, several projects were eliminated from consideration due to lack of necessary data.

Of the remaining 139 projects containing sufficient safety data, 47 utilized positive incentives, with the remaining 92 projects containing no safety incentives. The first comparison included projects from all cost categories, industry groups, and project types. Figure 4.9 shows the mean (average) RIR and LWCIR for these respective incentive use categories.

The RIR for each group of projects was nearly identical at 3.8 for the positive incentive group, and 3.9 for the no incentive group. Although additional research is certainly necessary, this may give the impression that recordable incidents are bound to happen regardless of incentive use, and may be more related to a companies long-standing safety procedures and philosophy. At a 95 percent confidence level, these two populations produced a z-value of -.173, which indicates acceptance of the null hypothesis, essentially meaning that there is no statistical difference between these two groups.

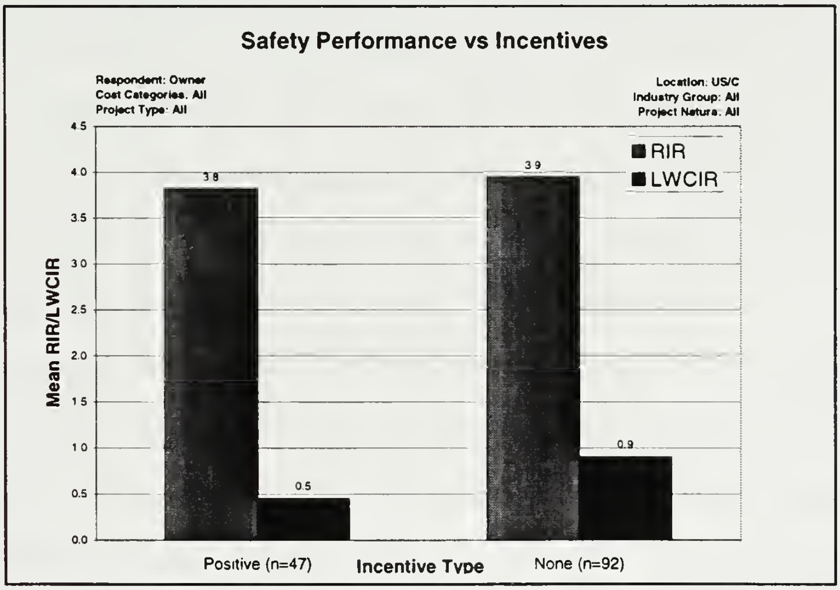

Figure 4.9: Effect of positive safety incentives on safety performance

Safety incentive employment did appear however to significantly reduce the LWCIR on a project. The 47 projects that employed safety incentives had a mean LWCIR of .5, compared to .9 for those projects with no safety incentives. Given the cost of a lost workday case, and the consequent effects on morale and productivity, this appears to be a significant result. Statistical analysis yielded acceptance of the null hypothesis, however, at 95 percent confidence with a z-value of -1.42. If the confidence level is reduced to 80 percent, the Null hypothesis could be rejected, indicating that these two groups are not the same. Although it is desired to have a confidence level of 90 percent or greater, one cannot ignore the significance of these results.

In order to further analyze the impacts of safety incentives, the projects were divided into two categories. The projects were split into those having greater than 250,000 craft-work-hours (CWH), and those having less than 250K CWH. This analysis will help determine the effect of safety incentives on projects of different sizes. The projects were only split into two categories because of the sample size did not allow for the separation into four categories, in the manner that CII typically does in most analyses. Figures 4.10 and 4.11 show the results of this analysis for the RIR and LWCIR respectively.

Consistent with the previous analysis, the average RIR was nearly equal for both groups, with the projects employing safety incentives producing a slightly lower average RIR. The 19 incentive based projects having less than 250K CWH produced an average RIR of 3.6. The 67 non-incentive based projects having less than 250K CWH produced an average RIR of 3.9. Statistical

analysis of these two groups indicates that they are essentially the same at any significant confidence level.

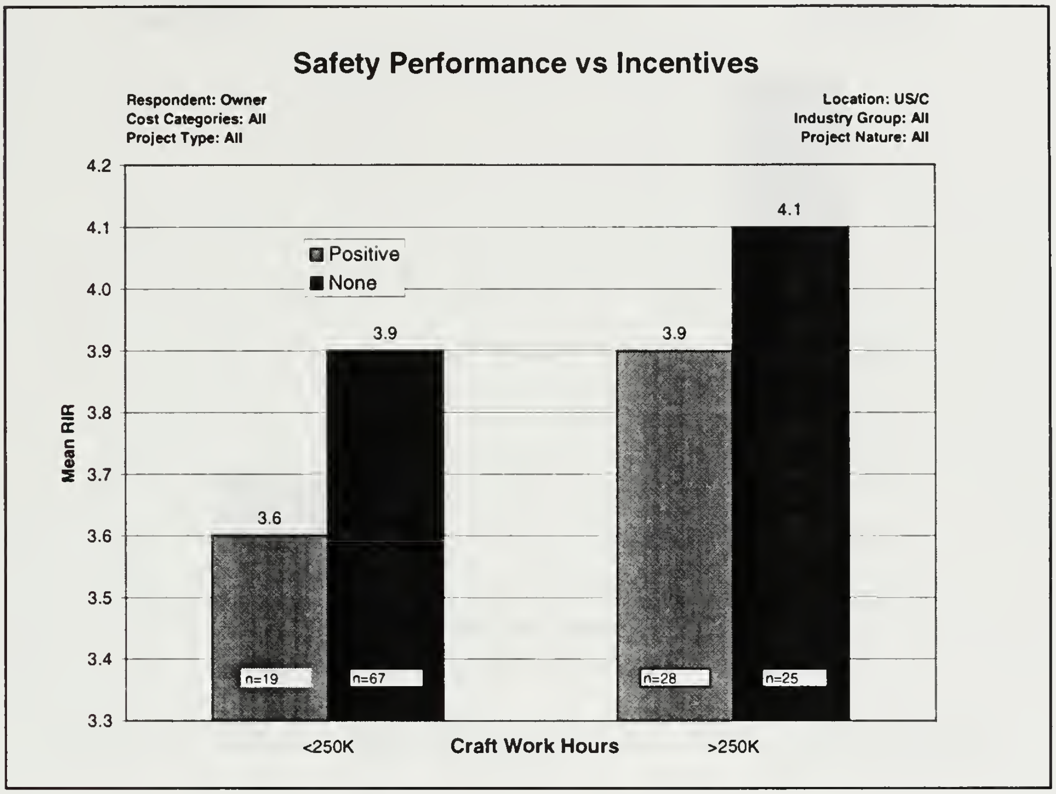

Figure 4.10: Effect of safety incentives on the RIR (CWH dependent)

The average RIR for the 28 incentive based projects containing more than 250K CWH was 3.9, compared to a 4.1 for the 25 non-incentive based projects over 250K CWH. Statistical analysis provided for acceptance of the null hypothesis for these two groups as well. Safety incentive use did not seem to have an impact on the RIR of these projects.

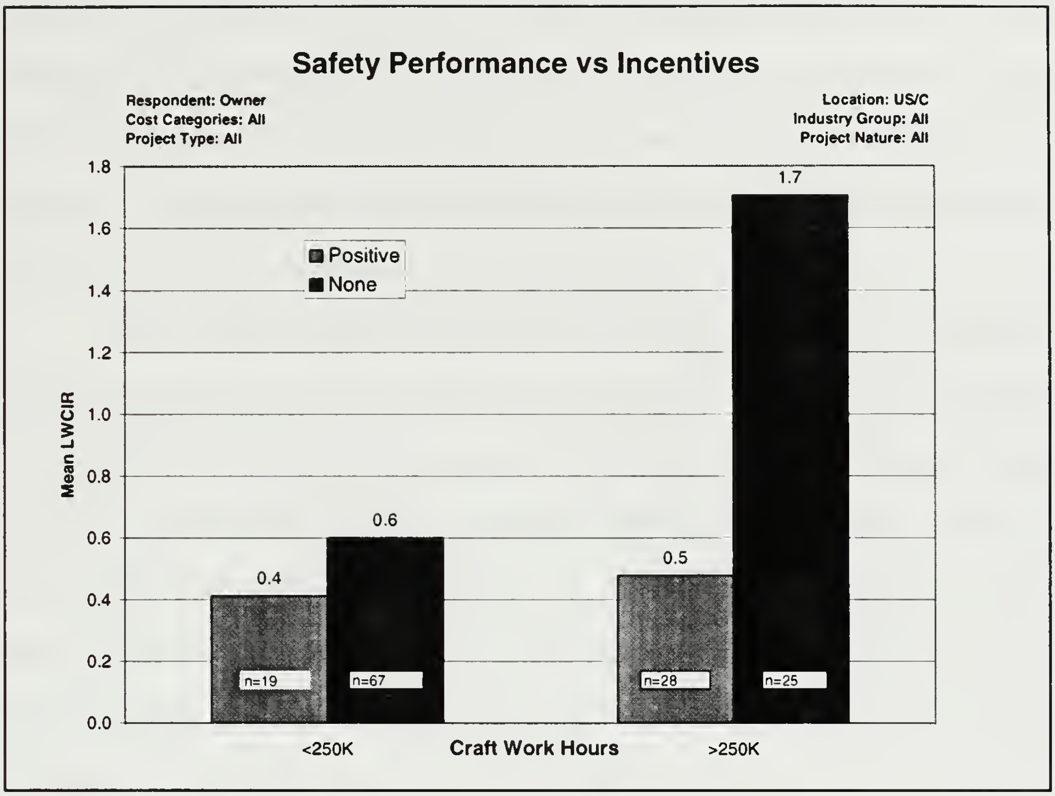

Figure 4.11: Effect of safety incentives on the LWCIR (CWH dependent)

The comparison of the LWCIR proved to be more interesting. The projects below 250K CWH provided an essentially equal comparison, however those projects with more than 250K CWH proved to differ significantly in their corresponding LWCIR. Figure 4.11 first compares 19 projects with incentives to 67 projects without incentives (< 250K CWH). The incentive-based projects had a slightly lower average rate at .4, compared to .6 for the non-incentive based projects. Statistical analysis showed these two groups to be essentially the same.

The second comparison that included in Figure 4.11 concerns projects containing more than 250K CWH. The 28 projects with safety incentives

produced an average LWCIR of .5, while 25 projects containing no safety incentives had an average LWCIR more than three times that amount at 1.7. Even at 95% confidence, these two groups are not the same, thus we can reject the null hypothesis and it can be concluded that safety incentives are effective in reducing the LWCIR on a project, especially on larger projects.

These analyses indicate that safety incentives may help one realize a significant reduction in project accidents, at least lost workday cases. Although it is not clearly evident that safety incentives reduce the RIR on a project, the fact that they can reduce the LWCIR is significant, and could have a larger impact on any project as a whole. Positive incentives will encourage contractors to plan better for safe work practices and to instill more awareness in their crews. The consequent effects of this will likely apply to major items of work. Even without a reduction in the RIR, the fact that the LWCIR can be reduced with incentives gives ample reason alone for their employment.

4.3 Cost Incentives vs. Cost Growth

The next research question that will be discussed is whether positive cost incentives actually lower cost growth. After screening the database for the appropriate cost growth information, 161 projects remained for analysis. Of these projects, 39 employed the use of positive cost incentives or a combination of positive and negative. Figure 4.12 shows that these projects had an average cost growth of only 2.7 percent. The remaining 122 projects that did not employ any cost incentives experienced an average cost growth of 4.7 percent, 2 percent

higher than the group utilizing cost incentives. These projects were from every cost category, industry type, and project nature.

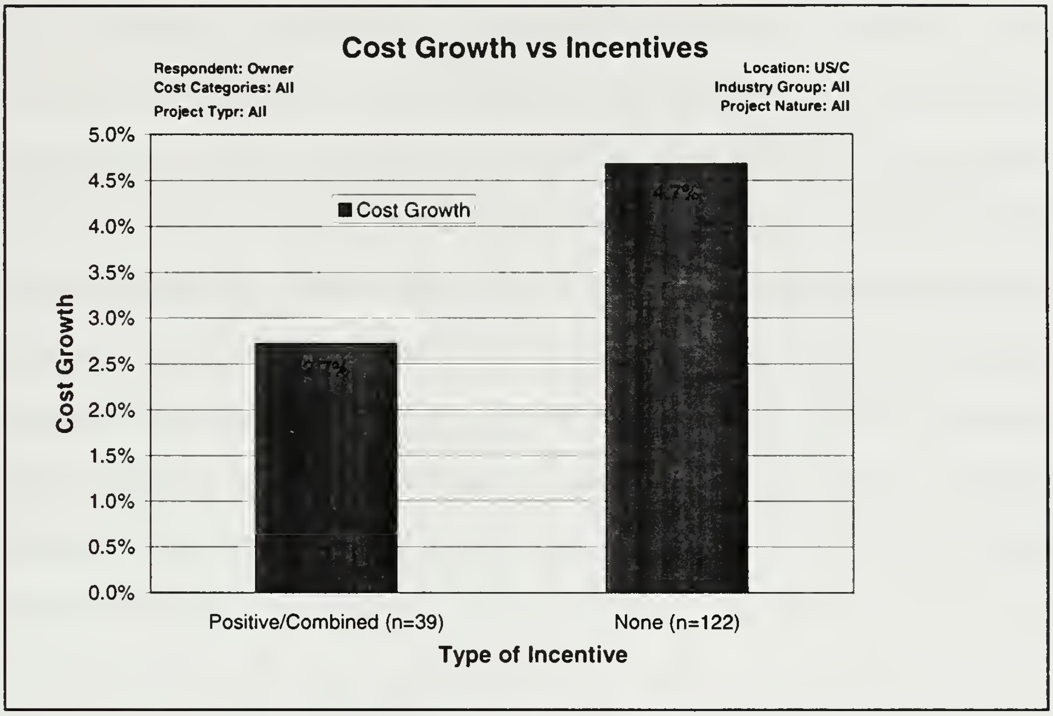

Figure 4.12: Effect of cost incentives on cost growth

Statistical analysis, however, indicated that these two groups of data were essentially the same in terms of cost growth, even though the non-incentive group had an average cost growth more than twice that of the incentive group.

Certainly additional data is needed to accurately quantify the effects of cost incentives on cost growth. One needs to also take into account for any changes, both owner requested and from other reasons. The reimbursement type of a project, whether it is lump sum or cost-reimbursable, also likely has a significant impact on the impact of any cost incentive employed.

4.4 SCHEDULE INCENTIVES VS. SCHEDULE GROWTH

The next analysis was a test on whether or not positive schedule incentives (or combination positive/negative) contributed to a reduction in schedule growth. As shown in Figure 4.13, these projects were compared with those projects utilizing only negative incentives or no schedule incentives at all. One-hundred fifty-nine projects remained for analysis after the data were screened for the appropriate schedule growth information. A total of 44 projects employed either positive or a combination of positive & negative schedule incentives. This group of projects produced an average cost growth of 5.08 percent. The 115 remaining projects that did not employ schedule incentives, or did so only in a negative fashion, experienced an average schedule growth of 9.32 percent, almost double that of the former.

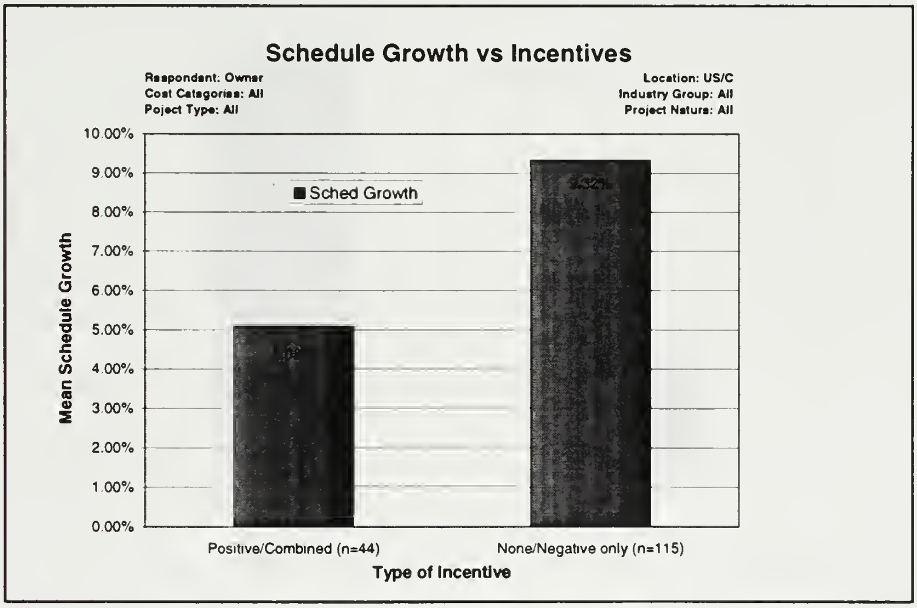

Figure 4.13:Effect of schedule incentives on schedule growth

The standard deviations in both groups were fairly large and statistical analysis of the results yielded a z-value of -.934, well within the acceptance range of the null hypothesis. These two samples therefore, are considered the same in terms of schedule growth.

This report also endeavored to determine if the use of only negative schedule incentives was counterproductive to schedule growth. Unfortunately only seven projects were available that employed only negative schedule incentives. These seven projects were compared with the remainder of the 159 projects considered in the previous analysis. This comparison is shown in Figure 4.14.

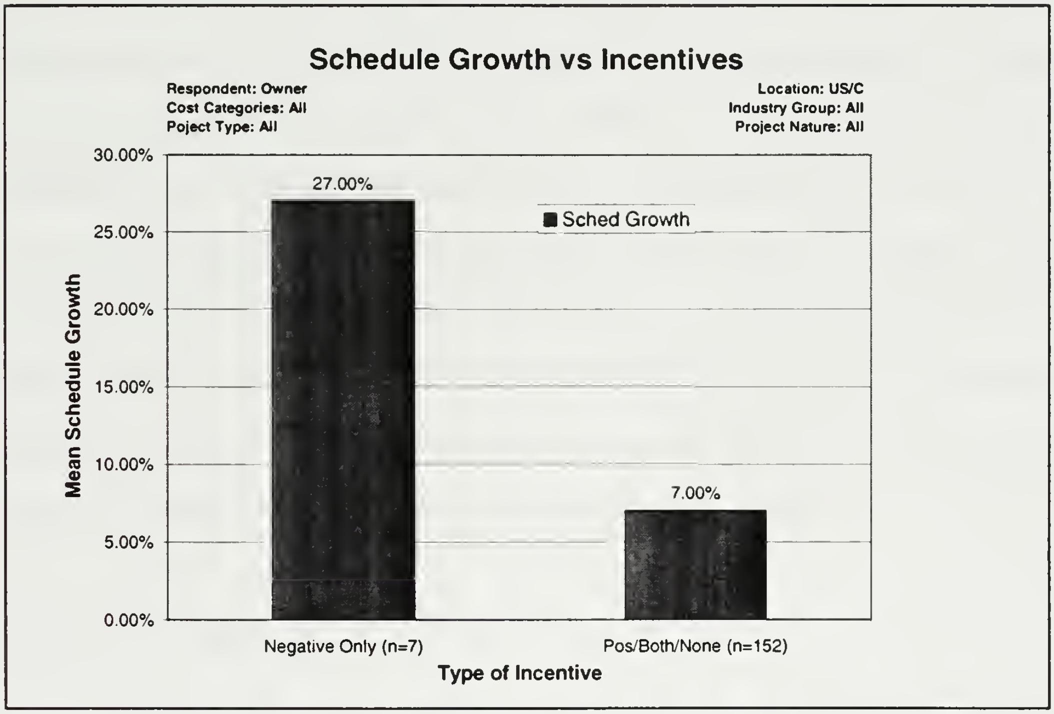

Figure 4.14: Effect of negative schedule incentives on schedule growth

"Negative only" schedule incentives produced a whopping average schedule growth of 27 percent in this small group of projects. Although this small sample is not considered statistically reliable, it is nonetheless interesting and should spark interest for further analysis. The remaining projects, totaling 152 when combined, had an average schedule growth of 7 percent. Statistical analysis yielded a z-value of –1.82, which although in the range of null-hypothesis-acceptance at 95 percent confidence, falls outside this range when the confidence value is reduced to 90 percent, indicating that these two groups can be considered different in terms of schedule growth at 90 percent confidence.

Since this comparison involved a small number of projects utilizing a "negative-only" incentive approach, the t-statistic was also calculated. The t-value calculated, .208, indicated an acceptance of the null hypothesis at almost any level of significance, however, giving further indication that the two sample populations are essentially the same in terms of schedule growth. Additional "negative only" projects should be analyzed so that the impact of "negative only" schedule incentives can be confidently ascertained. This information should prove valuable to most public contracting entities, since most public contracts contain a "liquidated damages" clause without any provisions for additional contractor compensation in the case of on-time or early completion.

4.5 Analysis Summary

The following tables contain a summary of the results and the statistical analysis done for each comparison made thus far.

Table 4.1: Summary of Safety Analysis (overall)

Safety Analysis (Overall)	Mean RIR	Std Dev	Mean LWCIR	Std Dev
Positive Incentives	3.8	3.52	0.5	0.8
vs.				
No Incentives	3.9	5.09	0.9	2.81
z-value	-0.173		-1.42	
Accept Null Hypothesis?				
95% Confidence	Y		Y	
90% Confidence	Y		Y	
80% Confidence	Y		N	

Table 4.2: Summary of safety analysis (< 250K cwh)

(<250K CWH)	Mean RIR	Std Dev	Mean LWCIR	Std Dev
Positive Incentives	3.6	3.87	0.4	0.86
Vs.				
No Incentives	3.9	5.26	0.6	1.64
z-value	-0.244		-0.664	
Accept Null Hypothesis?				
95% Confidence	Y		Y	
90% Confidence	Y		Y	

Table: 4.3: Summary of safety analysis (>250K cwh)

Safety Analysis (cont'd) (>250 K CWH)	Mean RIR	Std Dev	Mean LWCIR	Std Dev
Positive Incentives	3.9	3.32	0.5	0.77
Vs.				
No Incentives	4.1	4.67	1.7	4.65
z-value	-0.171		-2.06	
Accept Null Hypothesis?				
95% Confidence	Y		N	
90% Confidence	Y		N	

Table 4.4: Summary of cost growth analysis

Cost Analysis	Mean Cost Growth	Std Dev
Positive/Combined Incentives	0.027	0.261
Vs.		
Negative/No Incentives	0.047	0.334
z-value	-0.38	
Accept Null Hypothesis?		
95% Confidence	Y	
90% Confidence	Y	

Table 4.5: Summary of schedule growth analysis

Schedule Analysis	Mean Schedule Growth	Std Dev
Positive/Combined Incentives	0.051	0.241
Vs.		
Negative/No Incentives	0.093	0.292
z-value	-0.934	
Accept Null Hypothesis?		
95% Confidence	Y	
90% Confidence	Y	

Table 4.6: Summary of schedule growth analysis (negative-only incentives)

Schedule Analysis	Mean Schedule Growth	Std Dev
Negative Only Incentives	0.27	0.28
Vs.		
All others	0.073	0.277
z-value	-1.82	
t-value	.208	
Accept Null Hypothesis?		
95% Confidence	Y	
90% Confidence	N (Y w/ t-value)	

4.6 Incentive Use Index vs. Project Performance

The incentive use index developed for purposes of this research also provided interesting results. As previously discussed, this index is simply the total number of incentives employed during the construction phase for a particular project. If a positive cost incentive is used, the incentive use index would equal one. If both a positive and negative cost incentive is used, the incentive use index is equal to two. The range for this research is from zero to six, since only three incentive type were evaluated (safety, cost, and schedule). This idea was developed in order to determine whether a higher index produces better or worse project performance in terms of safety, cost, and schedule. Projects that have an index between zero and one will be compared to projects with an index between two and six

.

4.6.1 Safety Performance

A total of 138 projects were available to make the analysis on safety performance. Figure 4.15 shows that both the average RIR and LWCIR were similar in each group. There were 46 projects indicating an incentive use index of greater than two, and these projects experienced an average RIR of 4.1 and an average LWCIR of 0.7. The projects with an index less than two, 92 in all, experienced slightly better performance with an average RIR of 3.8 and an average LWCIR of 0.5.

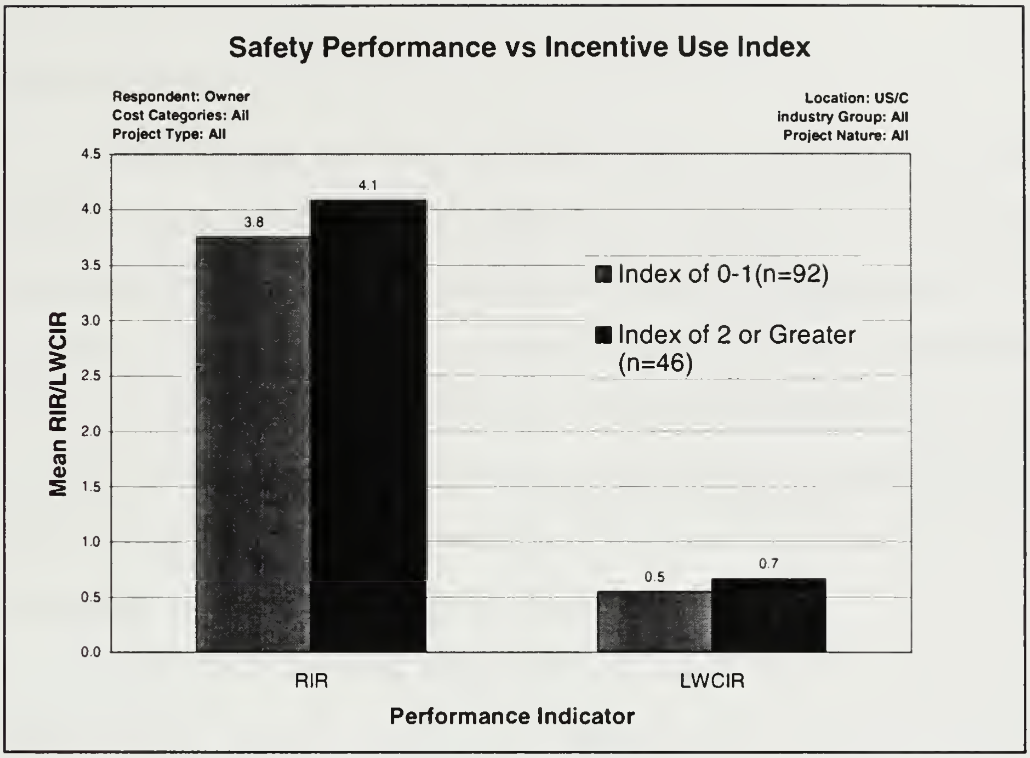

Figure 4.15: Incentive use index vs. overall safety performance

These results are interesting and could suggest that too many incentives employed, especially if geared towards cost and schedule performance, could be detrimental to the overall safety performance of a project. The trend shown for this sample indicates that when too many incentives are employed, contractors may lose their focus on safety, however, statistical analysis indicates that these two groups are essentially the same in terms of safety performance.

4.6.2 Cost Growth

After screening the data, 148 projects were left to conduct the same analysis on cost growth, shown in Figure 4.16. A total of 44 projects had an incentive use index greater than 2, while the remaining 104 projects had an index less than 2. The 44 projects in the higher use range produced an impressive overall average cost growth of –2.0 percent. The group of projects with a lower use index experienced an average cost growth of 4 percent, for a total difference of 6% between the two groups. Given the average cost of the projects in the data, this amounts to a significant amount of money.

Quantitatively speaking, these results are significant. On a hypothetical project worth $50 million, analysis of this sample indicates that higher incentive use correlates to six percent savings, or $3 million.

Statistical analysis yielded a z-value of 1.86, which although means acceptance of the Null hypothesis at 95 percent confidence (just barely), at 90 percent confidence, the Null hypothesis may be rejected and it may be concluded that these two groups are different when it comes to cost growth. If it can be confidently shown that safety performance does not suffer as a result of greater incentive use, the fact that one is more likely to achieve reduced cost growth if a greater number of incentives are used will likely make them a popular tool for improving project results.

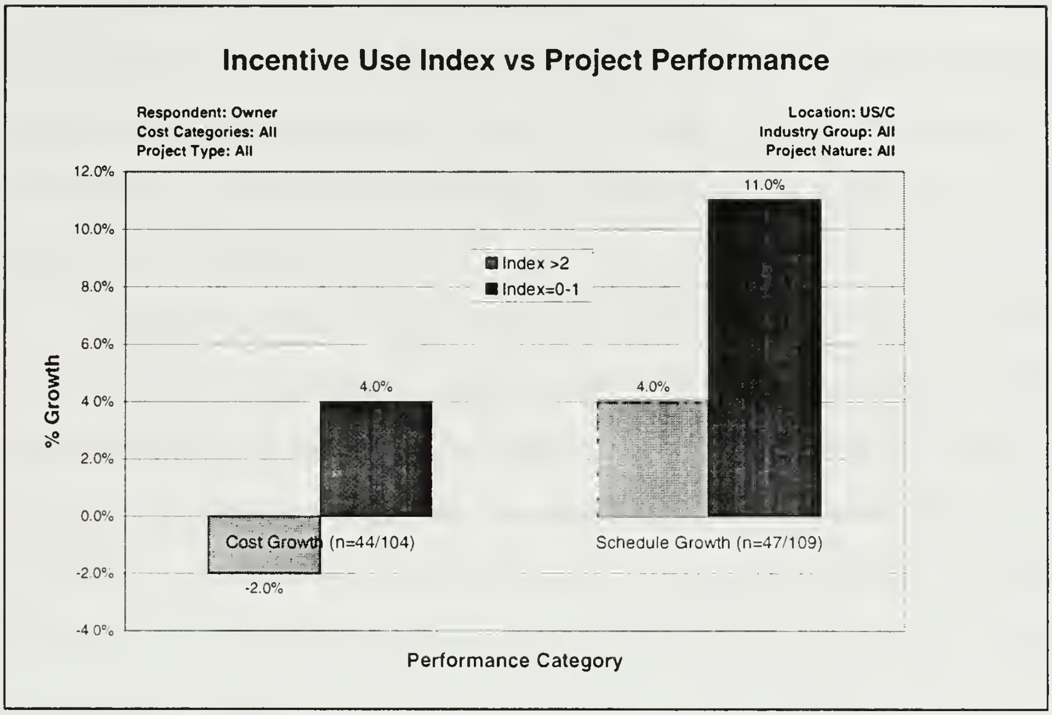

Figure 4.16: Incentive use index vs. project performance

4.6.3 Schedule Growth

The analysis of the impact of the incentive use index on schedule performance produced results consistent with that of the cost growth analysis, and is also shown in Figure 4.16. The group of projects with an index greater than two, 47 in all, indicated an average schedule growth of 4 percent. This number is much lower than the 11 percent average schedule growth reported by the projects with an index of less than two (109 in all).

Assuming a project is worth $50 million, with a 24 month duration and an assumed 18 percent return on investment (ROI); analysis of this sample indicates a seven percent schedule growth reduction, 1.7 months in all. Combine that with 1.5% (ROI) per month times $50 million, and this results in a savings of $1.25 million from the schedule savings.

Statistical analysis of this comparison yielded a z-value of 1.78, which again, at 95 percent confidence, means acceptance of the null hypothesis. At 90 percent confidence, however, the null hypothesis may be rejected and it may be said that a higher incentive use index appears to produce lower schedule growth on a project. Similar to the cost growth analysis, as long as it can be shown that safety performance does not suffer as a result of increased incentive use, it seems that incentive packages can reduce not only cost, but the schedule as well.

4.6.4 Summary of Incentive Use Index research

The tables on the following pages summarize the aforementioned results.

Table 4.7: Summary of Incentive Use Index vs. safety performance

Use Index Performance Safety	Mean RIR	Std Dev	Mean LWCIR	Std Dev
0-1	3.8	4.68	0.5	1.09
vs.				
2-6	4.1	4.48	0.7	1.81
z-value	-0.4		-0.4	
Accept Null Hypothesis?				
95% Confidence	Y		Y	
90% Confidence	Y		Y	

Table 4.8: Summary of Incentive Use Index vs. cost growth

Cost Growth Analysis	Mean Cost Growth	Std Dev
0-1	0.04	0.256
Vs.		
2-6	0.02	0.151
z-value	1.78	
Accept Null Hypothesis?		
95% Confidence	Y	
90% Confidence	N	

Table: 4.9: Summary of Incentive Use Index vs. schedule growth

Schedule Growth Analysis	Mean Schedule Growth	Std Dev
0-1	0.11	0.259
Vs.		
2-6	0.04	0.208
z-value	1.85	
Accept Null Hypothesis?		
95% Confidence	Y	
90% Confidence	N	

Chapter 5: Conclusions and Recommendations

5.1 Conclusions

This thesis has shown that certain contract incentives, employed by owners to encourage a contractor to help the owner reach their goals and objectives, are effective, while the employment of others has shown to be, at best, marginally effective for the sample studied. The following paragraphs offer conclusions reached from the analysis conducted in Chapter 4 as well as recommendations for procurement agencies (included at the end of this chapter). Please note that these conclusions are valid for this sample only, but do shed light on a subject that has had little empirical study.

Public entities seem to shy away from the use of incentives, especially when compared to private entities. This is evident when one looks at the average use of cost and safety incentives. Just over 11 percent of public projects in the sample reported the use of cost incentives, and even less, 8.6 percent reported the use of safety incentives. There are many explanations for these low usage rates, none more obvious than the fact that public entities are usually constrained by laws dictating the acceptance of the dreaded "low bid." In this type of procurement method, the contractor bears the majority of risk, thus public entities may not realize any benefits from the use of these incentives anyway. If perhaps the remuneration type were different cost reimbursable for instance, then these types of incentives would be a more feasible option.

In contrast, private contracts in the sample reported much higher incentive use rates at approximately 30 percent for each of the incentive types studied. Private firms are at greater liberty to determine their procurement strategy, and are likely benefiting.

Of no surprise was the fact that public entities did employ a significant amount of schedule incentives. Over 48 percent of the public projects submitted reported the use of schedule incentives, albeit 11 of the 16 reporting them utilized negative-only incentives. The preponderance of liquidated damages clauses in public contracts, with no commensurate reward for early completion, seems to be counterproductive. Private owners apparently have recognized this, since only three of the 47 private projects in the sample reporting a schedule incentive used a "negative-only" approach.

Incentive use among the various industry types was fairly evenly dispersed, with heavy industrial projects showing a 40 percent usage rate for cost, schedule, and safety incentives respectively. The use rate among each nature of project (add-on, grass roots, and modernization) was also fairly even at approximately 30 percent for each incentive type. The only project type that really showed any difference was grass roots projects, where over 41 percent reported the use of schedule incentives versus 30 percent for the other two types of projects. Incentive use was again shown to be more prevalent in private projects when the average Incentive Use Index was calculated for both private and public projects. Private entities had a 33 percent higher average use index at 1.2, versus the 0.8 calculated for the public projects. As the analysis in Chapter 4

indicates, private entities are benefiting, especially in the areas of reduced schedule growth and reduced cost growth.

The use of safety incentives in the sample was shown to improve project safety performance. Positive safety incentives employed on projects containing over 250,000 craft-work-hours have resulted in a drastic reduction in the average LWCIR. This reduction in the LWCIR is also evident on projects of all sizes, albeit at a lower confidence. Owners cannot ignore these results considering both the economic and humanitarian benefit of improved safety.

Positive/combined cost incentives in this sample did show a trend towards reduced cost growth, however, adequate statistical significance could not be attained. It is likely that with additional research the statistical criteria could be satisfied. Given the potential savings to owner entities and the seemingly high use rate of positive cost incentives, certainly more research is needed in this area. If it cannot be proven that they reduce cost, why employ them in the first place?

The use of positive/combined schedule incentives in this sample did indicate a lower potential for schedule growth. Similarly, negative-only incentives did seem to hinder project schedule performance, with the projects employing them in this sample showing an average schedule growth almost four times that of those projects with no schedule incentives or positive/combined schedule incentives. Although only a small number of projects reported the use of negative incentives, these results are startling nonetheless, especially to the public sector which often includes a liquidated damages clause in a contract without much thought. Similar to cost incentives, however, the analysis of schedule

incentives did not pass the rigorous statistical testing, and further analysis with more data is needed to confirm these apparent trends.

The incentive use index analysis yielded some interesting results. While an increased amount of incentives did not necessarily improve safety performance (nor did it adversely affect it), utilizing 2 or more incentives on a project resulted in drastic reductions in both cost growth as well as schedule growth.

5.2 Recommendations

Based on the analysis of this sample, the following recommendations are offered to any entity engaged in the procurement of construction related services:

- Utilize safety incentives to the maximum extent. The benefits of a lower LWCIR are invaluable;
- Avoid the use of "negative-only" schedule incentives, particularly liquidated damages clauses. These clauses immediately create an adversarial relationship between the owner and contractor and are counterproductive to reducing the project duration;
- If incentives are desired, utilize a "packaged" approach. By using 2 or more incentives, the chances are increased that the project will experience both reduced cost growth and reduced construction duration.

- Do not blindly include incentives in any contract. Owner entities should become educated on incentive use and realize that incentives should be designed to reward contractors for desired behavior, not to reward the assumption of additional risk.
- Additional research should be conducted on the impact of incentive use when larger samples become available.

Appendix A: Analysis Data

cii_id_a	version	type	char	pubpriv	cii_cntr	cnsttype	concost
O1	Version 1	Dormatory/	Grass Roo	Public	0	LS	4
O10	Version 1	Electrical ((	Modernizat	Private	0	LS	4
O100	Version 1	Microelectr	Add-on	Private	0	CR	1
O101	Version 1	Highrise O	Grass Roo	Private	0	CR	1
O102	Version 1	Microelectr	Add-on	Private	0	CR	1
O11	Version 1	Water/Was	Add-on	Private	0	LS	4
O12	Version 1	Chemical M	Add-on	Private	100	CR	4
O13	Version 1	Chemical M	Modernizat	Private	100	CR	4
O14	Version 1	Chemical M	Add-on	Private	60	CR	4
O15	Version 1	Chemical M	Modernizat	Private	90	CR	3
O16	Version 1	Chemical M	Grass Roo	Private	100	CR	3
O19	Version 1	Water/Was	Add-on	Private	0	LS	4
O2	Version 1	Laboratory	Grass Roo	Public	0	LS	4
O20	Version 1	Pulp and P	Modernizat	Private	0	LS	4
O21	Version 1	Pulp and P	Add-on	Private	0	LS	4
O22	Version 1	Chemical M	Grass Roo	Private	0	CR	1
O23	Version 1	Chemical M	Grass Roo	Private	0	LS	1
O24	Version 1	Chemical M	Modernizat	Private	0	LS	4
O25	Version 1	Chemical M	Add-on	Private	0	CR	4
O26	Version 1	Laboratory	Grass Roo	Private	0	GP	1
O27	Version 1	Pulp and P	Modernizat	Private	0	LS	4
O28	Version 1	Pulp and P	Grass Roo	Private	0	CR	1
O29	Version 1	Laboratory	Modernizat	Public	0	LS	4
O3	Version 1	Marine Fac	Modernizat	Public	0	LS	4
O30	Version 1	Lowrise Of	Modernizat	Public	0	LS	4
O31	Version 1	Lowrise Of	Grass Roo	Public	0	LS	4
O32	Version 1	Lowrise Of	Modernizat	Public	0	LS	4
O33	Version 1	Laboratory	Grass Roo	Private	16	LS	4
O35	Version 1	Pharmaceu	Add-on	Private	0	LS	4
O36	Version 1	Pharmaceu	Modernizat	Private	0	LS	4
O37	Version 1	Metals Ref	Modernizat	Private	100	LS	4
O38	Version 1	Lowrise Of	Modernizat	Private	0	GP	4
O39	Version 1	Automotive	Modernizat	Private	0	LS	4
O4	Version 1	Maintenan	Grass Roo	Public	0	LS	4
O40	Version 1	Automotive	Add-on	Private	0	LS	4
O41	Version 1	Automotive	Modernizat	Private	-9	Unk	4
O42	Version 1	Lowrise Of	Grass Roo	Private	0	CR	4
O43	Version 1	Lowrise Of	Add-on	Private	0	CR	4
O44	Version 1	Oil Refinin	Modernizat	Private	10	LS	4
O45	Version 1	Lowrise Of	Grass Roo	Public	0	LS	4
O47	Version 1	Natural Ga	Grass Roo	Private	0	LS	1

conschd	consafe	Inc Indx	crftwkhr	recrdinj	lstwkdc	RIR	LWCIR
3	4	2	275953	0	0	0	0
4	4	0	85423	0	0	0	0
1	1	3	27630	0	0	0	0
1	1	3	145836	11	2	15.08544	2.742807
1	1	3	1152930	31	0	5.377603	0
4	4	0	189500	17	4	17.94195	4.221636
4	4	0	63165	1	0	3.16631	0
3	4	2	63000	6	0	19.04762	0
4	4	0	-999	-999	-999	200000	200000
4	4	2	-999	-999	-999	200000	200000
4	1	3	1120000	-999	-999	-178.393	-178.393
4	4	0	69000	5	0	14.49275	0
2	4	1	275000	2	2	1.454545	1.454545
1	4	1	25375	2	0	15.76355	0
3	4	2	27975	2	0	14.29848	0
4	1	2	1117000	21	1	3.760072	0.179051
1	1	3	410000	5	0	2.439024	0
4	1	1	86000	1	0	2.325581	0
4	4	0	120000	1	0	1.666667	0
4	4	1	186000	6	1	6.451613	1.075269
4	1	1	275818	8	1	5.800927	0.725116
1	1	3	637000	38	9	11.93093	2.825746
2	4	1	62800	0	0	0	0
2	4	1	130000	0	0	0	0
2	4	1	-999	-999	-999	200000	200000
2	4	1	280000	4	3	2.857143	2.142857
4	4	0	-999	-999	-999	200000	200000
4	4	0	-999	-999	-999	200000	200000
4	4	0	135000	6	1	8.888889	1.481481
4	4	0	90000	4	0	8.888889	0
4	4	0	-999	-999	-999	200000	200000
4	4	0	1000000	8	-999	1.6	-199.8
4	4	0	478774	52	15	21.72215	6.266004
2	4	1	126000	0	0	0	0
4	4	0	112000	0	0	0	0
4	4	0	-999	-999	-999	200000	200000
4	4	0	391409	4	0	2.043898	0
4	4	0	496000	14	0	5.645161	0
4	1	1	300000	6	4	4	2.666667
4	4	0	-999	-999	-999	200000	200000
2	4	2	40887	2	2	9.783061	9.783061

q_23	cli_id_c	prbudget	projcost	budcscon	actcscon	Cost Grth	plncon_s
2	O1	19400000	19900000	18373000	18873000	0.027214	10/1/93
1	O10	22461000	21533000	9512000	7926000	-0.16674	7/1/94
1	O100	17600000	17800000	-999	-999	0	9/9/09
1	O101	15200000	13800000	-999	-999	0	9/9/09
1	O102	1.34E+08	1.2E+08	-999	-999	0	9/9/09
2	O11	38237000	40197000	5250000	18164000	2.45981	9/9/09
2	O12	10600000	7720000	-999	5965000	-5971.97	9/9/09
1	O13	23000000	21900000	12040000	10020000	-0.16777	1/15/95
2	O14	47050000	58400000	32450000	40600000	0.251156	3/1/93
2	O15	1.24E+08	1.27E+08	60000000	62800000	0.046667	2/1/94
8	O16	3.68E+08	3.54E+08	1.85E+08	1.77E+08	-0.04324	5/1/92
2	O19	24000000	21500000	23600000	21100000	-0.10593	7/30/94
2	O2	64800000	75132000	55089000	65132000	0.182305	9/15/91
2	O20	7648000	6440000	2900000	2447000	-0.15621	9/19/94
2	O21	7419000	6413000	2253000	1974000	-0.12383	7/1/94
1	O22	1.36E+08	1.24E+08	62100000	55100000	-0.11272	4/15/94
1	O23	44300000	48300000	23076000	26576000	0.151673	3/15/95
1	O24	13300000	13632000	7245000	7553000	0.042512	3/15/94
2	O25	15580000	10403000	9457000	6089000	-0.35614	12/15/92
1	O26	23400000	22700000	20130000	19485000	-0.03204	7/15/93
1	O27	51000000	44600000	19009000	15015000	-0.21011	1/20/93
1	O28	65000000	70900000	26200000	35683000	0.361947	7/15/90
2	O29	5345000	5400000	5000000	5000000	0	7/9/93
1	O3	13996000	15934000	12692000	14532000	0.144973	9/9/09
1	O30	6246000	6192000	5700000	5650000	-0.00877	7/1/92
8	O31	46085000	43494067	42300000	40026000	-0.05376	4/30/92
2	O32	6665000	7500000	6330000	7080000	0.118483	9/1/90
1	O33	1.35E+08	1.4E+08	1.15E+08	1.19E+08	0.031113	9/9/09
2	O35	16000000	14500000	5750000	5500000	-0.04348	9/26/93
2	O36	15500000	15100000	5500000	4200000	-0.23636	7/1/94
2	O37	8000000	8200000	6500000	7300000	0.123077	6/30/95
1	O38	1.5E+08	1.5E+08	1.28E+08	1.32E+08	0.03125	4/9/93
1	O39	95400000	1.04E+08	90000000	97700000	0.085556	1/23/95
2	O4	17600000	16947000	-999	14897000	-14912.9	9/9/09
2	O40	34000000	29800000	32300000	28311000	-0.1235	9/12/94
2	O41	56400000	56000000	51900000	-999	-1.00002	8/24/92
1	O42	31090000	28281000	28190000	25474000	-0.09635	9/9/09
1	O43	36920000	39100000	33120000	34700000	0.047705	7/23/93
2	O44	1.03E+08	95000000	43985000	31057000	-0.29392	1/15/94
8	O45	84000000	79470000	56000000	68000000	0.214286	2/15/91
2	O47	13169000	12430000	3628000	3730000	0.028115	7/19/95

plncon_f	actcon_s	actcon_f	Scd Grth
12/22/94	10/15/93	3/15/95	0.15
7/7/95	6/1/94	3/15/95	-0.23
9/9/09	9/9/09	9/9/09	#DIV/0!
9/9/09	9/9/09	9/9/09	#DIV/0!
9/9/09	9/9/09	9/9/09	#DIV/0!
9/9/09	11/1/92	3/30/94	#DIV/0!
9/9/09	8/1/94	6/1/95	#DIV/0!
7/15/95	1/15/95	8/30/95	0.25
2/18/94	3/1/93	6/1/94	0.29
1/15/95	3/15/94	5/1/95	0.18
5/1/94	6/15/92	5/19/94	-0.04
12/31/95	8/19/94	12/15/95	-0.07
9/15/93	10/21/91	4/29/94	0.26
12/22/94	10/3/94	12/12/94	-0.26
5/15/95	6/15/94	3/15/95	-0.14
4/15/95	3/15/94	6/15/95	0.25
1/15/96	3/15/95	2/15/96	0.10
2/15/95	3/15/94	2/15/95	0.00
11/15/93	2/15/93	9/15/93	-0.37
4/15/95	7/15/93	1/15/95	-0.14
10/9/95	1/20/93	10/18/95	0.01
11/26/91	8/13/90	4/13/92	0.22
1/1/95	7/19/93	2/17/95	0.07
9/9/09	4/15/92	3/15/94	#DIV/0!
7/1/94	8/18/92	2/29/96	0.77
4/1/94	6/22/92	5/30/95	0.53
10/1/91	6/15/91	12/15/92	0.39
9/9/09	2/1/90	12/1/93	#DIV/0!
11/20/94	11/15/93	4/14/95	0.23
11/30/95	9/1/94	11/30/95	-0.12
11/6/95	7/5/95	12/15/95	0.26
12/28/95	10/2/93	4/1/96	-0.08
4/1/96	4/17/95	7/1/96	0.02
9/9/09	11/9/92	7/5/95	#DIV/0!
6/30/95	9/12/94	7/26/95	0.09
8/27/93	9/9/09	9/9/09	-1.00
9/9/09	7/22/93	9/7/95	#DIV/0!
4/30/96	7/23/93	4/22/96	-0.01
10/15/95	11/15/93	1/15/96	0.24
4/14/94	4/16/91	2/1/96	0.52
10/15/95	7/26/95	9/9/09	-357.43

cii_id_a	version	type	char	pubpriv	cii_cntr	cnsttype	cost_inc
O48	Version 1	Natural Ga	Grass Roo	Private	0	LS	1
O49	Version 1	Electrical ((	Grass Roo	Private	100	LS	4
O5	Version 1	Hospital	Grass Roo	Public	0	LS	4
O50	Version 1	Natural Ga	Add-on	Private	0	LS	4
O51	Version 1	Natural Ga	Grass Roo	Private	0	LS	4
O52	Version 1	Environme	Grass Roo	Private	0	GP	4
O53	Version 1	Chemical M	Modernizat	Private	0	LS	4
O54	Version 1	Chemical M	Add-on	Private	0	CR	4
O55	Version 1	Chemical M	Add-on	Private	0	LS	4
O56	Version 1	Chemical M	Add-on	Private	0	LS	4
O57	Version 1	Chemical M	Add-on	Private	0	LS	4
O58	Version 1	Warehouse	Add-on	Private	0	LS	4
O59	Version 1	Water/Was	Add-on	Private	0	LS	4
O60	Version 1	Maintenan	Grass Roo	Private	0	LS	4
O61	Version 1	Water/Was	Modernizat	Private	0	LS	4
O62	Version 1	Consumer	Grass Roo	Private	0	GP	4
O63	Version 1	Consumer	Add-on	Private	0	CR	4
O64	Version 1	Consumer	Modernizat	Private	15	CR	4
O65	Version 1	Warehouse	Modernizat	Private	75	CR	4
O66	Version 1	Consumer	Add-on	Private	100	CR	4
O68	Version 1	Electrical ((	Grass Roo	Private	27	LS	4
O69	Version 1	Oil Refining	Add-on	Private	100	CR	4
O70	Version 1	Chemical M	Grass Roo	Private	100	GP	3
O71	Version 1	Oil Refining	Modernizat	Private	0	CR	1
O72	Version 1	Oil Refining	Add-on	Private	100	CR	4
O73	Version 1	Oil Refining	Grass Roo	Private	100	CR	4
O74	Version 1	Oil Refining	Modernizat	Private	100	CR	4
O75	Version 1	Oil Refining	Grass Roo	Private	100	CR	1
O76	Version 1	Oil Refining	Grass Roo	Private	100	CR	1
O77	Version 1	Chemical M	Grass Roo	Private	0	CR	1
O78	Version 1	Environme	Modernizat	Private	0	LS	4
O79	Version 1	Pulp and P	Modernizat	Private	0	CR	4
O8	Version 1	Electrical ((	Add-on	Private	95	I	4
O80	Version 1	Pulp and P	Modernizat	Private	0	LS	4
O81	Version 1	Pulp and P	Add-on	Private	75	CR	4
O82	Version 1	Chemical M	Add-on	Private	100	CR	3
O83	Version 1	Laboratory	Grass Roo	Private	0	CR	4
O84	Version 1	Laboratory	Grass Roo	Private	0	CR	4
O85	Version 1	Lowrise Of	Grass Roo	Private	100	CR	4
O86	Version 1	Electrical ((	Modernizat	Public	30	CR	4
O87	Version 1	Water/Was	Modernizat	Public	0	LS	4

schd_inc	safe_inc	Inc Indx	crftwkhr	recrdinj	lstwkdc	RIR	LWCIR
2	4	2	30791	0	0	0	0
3	4	2	373661	16	43	8.563912	23.01551
2	4	1	132815	2	2	3.011708	3.011708
4	1	1	-999	-999	-999	200000	200000
4	1	1	-999	-999	-999	200000	200000
4	4	0	216113	4	1	3.701767	0.925442
4	4	0	101000	0	0	0	0
4	1	1	69451	2	0	5.759456	0
1	1	2	54190	0	0	0	0
4	4	0	101044	1	0	1.979336	0
4	4	0	153590	3	1	3.906504	1.302168
4	4	0	51720	0	0	0	0
4	4	0	82000	3	0	7.317073	0
4	4	0	101357	2	0	3.946447	0
4	4	0	245000	2	0	1.632653	0
4	4	0	468508	9	1	3.841983	0.426887
4	4	0	106400	0	0	0	0
4	4	0	155862	1	1	1.283186	1.283186
4	4	0	205000	1	0	0.97561	0
4	4	0	404593	1	0	0.494324	0
4	1	1	548000	18	2	6.569343	0.729927
4	1	1	111398	2	0	3.590729	0
3	1	5	5000000	98	3	3.92	0.12
1	1	3	541269	-999	-999	-369.133	-369.133
1	1	2	240000	4	0	3.333333	0
4	4	0	298000	5	1	3.355705	0.671141
1	1	2	67560	1	0	2.960332	0
1	1	3	2784268	32	1	2.298629	0.071832
1	1	3	1093820	13	1	2.376991	0.182845
1	1	3	914000	8	0	1.750547	0
4	4	0	87328	0	0	0	0
4	4	0	320000	6	0	3.75	0
4	4	0	148000	4	0	5.405405	0
4	4	0	160000	8	1	10	1.25
4	4	0	148414	10	1	13.47582	1.347582
3	3	6	367532	5	2	2.720852	1.088341
4	4	0	128000	0	0	0	0
4	4	0	300000	16	4	10.66667	2.666667
4	4	0	1067000	22	9	4.123711	1.686973
4	4	0	84680	2	0	4.723666	0
4	4	0	-999	-999	-999	200000	200000

q_23	cli_id_c	prbudget	projcost	budcscon	actcscon	Cost Grth	plncon_s
2	O48	7981000	9012000	3296000	3519000	0.067658	6/22/95
2	O49	1.12E+08	1.07E+08	38051000	33054000	-0.13132	9/1/91
2	O5	16150000	11678000	-999	9752000	-9762.76	9/9/09
1	O50	9922000	10278000	2437000	3379000	0.386541	2/28/94
1	O51	8918000	8013000	2391000	2704000	0.130908	4/25/94
2	O52	13000000	12950000	-999	-999	0	6/1/91
2	O53	12555000	12975000	4746000	5348000	0.126844	3/1/95
1	O54	8039000	9790000	4685000	6962000	0.486019	5/1/95
1	O55	9300000	8700000	4734000	5311000	0.121884	9/7/94
1	O56	13750000	14550000	5735000	6425000	0.120314	4/1/95
2	O57	24400000	19400000	11990000	8310000	-0.30692	10/3/94
1	O58	6200000	5400000	3805800	3065000	-0.19465	11/2/92
1	O59	18300000	14600800	14948923	11765367	-0.21296	8/1/94
1	O60	10900000	8900000	9078000	7500000	-0.17383	6/1/93
1	O61	25400000	27919787	17502500	20821519	0.189631	12/1/93
1	O62	1.33E+08	1.32E+08	53617000	54055000	0.008169	8/15/93
2	O63	17750000	14819000	6025000	4415000	-0.26722	11/1/94
2	O64	11000000	10990000	7852000	7144000	-0.09017	3/1/94
2	O65	30500000	29750000	12000000	12000000	0	8/1/94
2	O66	33000000	32500000	18500000	17840000	-0.03568	3/6/95
2	O68	74800000	82300000	20900000	24300000	0.162679	11/15/94
1	O69	29800000	21100000	16725000	8000000	-0.52167	2/13/95
1	O70	4.61E+08	4.97E+08	2.23E+08	2.06E+08	-0.07742	8/15/92
2	O71	39575000	44575000	19403000	21892000	0.128279	3/1/95
2	O72	36700000	37900000	18100000	18700000	0.033149	5/1/93
2	O73	65700000	51700000	33100000	24300000	-0.26586	8/1/94
1	O74	12520000	12520000	3800000	3500000	-0.07895	7/1/94
1	O75	2.36E+08	2.08E+08	90600000	80800000	-0.10817	5/1/93
1	O76	1.12E+08	81380000	35400000	25800000	-0.27119	5/1/93
1	O77	1.54E+08	1.49E+08	58500000	45100000	-0.22906	5/1/93
2	O78	7301000	7360000	1200000	1300000	0.083333	6/8/94
1	O79	16671000	16722000	6989000	7326000	0.048219	2/1/95
1	O8	27200000	23000000	11390000	9681000	-0.15004	3/15/93
1	O80	16242000	17400000	7832000	8000000	0.02145	5/31/94
2	O81	10058000	11500000	3683000	4725000	0.282922	9/9/09
1	O82	56000000	61000000	29000000	30000000	0.034483	2/15/94
2	O83	16000000	14500000	14500000	12935000	-0.10793	8/1/93
2	O84	41000000	40925000	38485000	37965000	-0.01351	8/15/91
1	O85	1.6E+08	1.55E+08	1.44E+08	1.38E+08	-0.04097	1/1/90
2	O86	13144000	13634000	6112000	7121000	0.165085	10/10/95
2	O87	5360000	5600000	-999	-999	0	11/21/94

plncon_f	actcon_s	actcon_f	Scd Grth
10/15/95	7/29/95	11/19/95	-0.02
10/1/92	4/9/92	2/5/93	-0.24
9/9/09	11/8/93	8/10/95	#DIV/0!
10/3/94	2/28/94	12/19/94	0.35
9/26/94	4/25/94	10/3/94	0.05
10/30/92	11/1/90	4/1/93	0.71
12/5/95	3/1/95	1/12/96	0.14
11/15/95	5/1/95	11/27/95	0.06
9/1/95	9/7/94	1/1/96	0.34
2/15/96	3/26/95	1/19/96	-0.07
8/4/95	10/3/94	11/30/95	0.39
11/1/93	1/1/93	11/20/93	-0.11
8/1/95	8/1/94	8/15/95	0.04
8/4/94	5/24/93	1/31/94	-0.41
9/1/95	5/1/94	2/26/96	0.04
1/1/95	8/15/93	2/1/95	0.06
8/31/95	11/1/94	9/7/95	0.02
6/15/95	3/1/94	6/1/95	-0.03
2/1/96	8/1/94	6/1/96	0.22
11/20/95	4/3/95	2/12/96	0.22
1/31/96	10/1/94	5/15/96	0.34
12/29/95	7/5/95	12/15/95	-0.49
3/15/94	10/15/92	7/15/94	0.11
10/20/95	3/1/95	11/14/95	0.11
10/1/94	5/1/93	10/1/94	0.00
10/31/95	6/1/94	10/1/95	0.07
5/1/95	4/1/94	6/1/95	0.40
6/1/95	5/3/93	4/17/95	-0.06
6/1/95	5/1/93	3/24/95	-0.09
4/1/95	6/1/93	2/27/95	-0.09
5/2/95	6/8/94	5/4/95	0.01
6/30/95	3/1/95	9/30/95	0.43
6/15/95	7/15/93	12/15/95	0.07
6/15/95	5/31/94	10/15/95	0.32
9/9/09	2/1/95	7/15/95	#DIV/0!
10/15/95	4/15/94	7/15/95	-0.25
3/30/95	8/1/93	2/28/95	-0.05
6/30/93	8/15/91	12/30/93	0.27
12/31/94	1/1/90	10/31/94	-0.03
1/19/96	10/10/95	1/17/96	-0.02
12/24/95	11/21/94	9/9/09	-79.19

cii_id_a	version	type	char	pubprv	cii_cntr	cnsttype	concost
O88	Version 1	Electrical ((	Modernizat	Public	100	CR	4
O89	Version 1	Electrical ((	Modernizat	Public	100	CR	4
O90	Version 1	Electrical ((	Modernizat	Public	100	CR	4
O91	Version 1	Oil Refining	Add-on	Private	0	CR	4
O92	Version 1	Chemical M	Add-on	Private	100	CR	4
O93	Version 1	Chemical M	Add-on	Private	100	CR	4
O94	Version 1	Chemical M	Grass Roo	Private	100	CR	4
O95	Version 1	Chemical M	Modernizat	Private	70	CR	4
O96	Version 1	Water/Was	Grass Roo	Private	100	CR	4
O97	Version 1	Chemical M	Grass Roo	Private	100	CR	1
O98	Version 1	Lowrise Of	Grass Roo	Private	0	GP	1
O99	Version 1	Microelectr	Grass Roo	Private	0	CR	1
O103	Version 2	Water/Was	Modernizat	Private	0	LS	1
O104	Version 2	Laboratory	Grass Roo	Private	0	GP	1
O105	Version 2	Oil Refining	Modernizat	Private	0	CR	1
O106	Version 2	Marine Fac	Add-on	Private	100	CR	1
O107	Version 2	Oil Refining	Modernizat	Private	0	CR	1
O108	Version 2	Environme	Grass Roo	Private	100	CR	1
O109	Version 2	Oil Refining	Add-on	Private	70	CR	4
O110	Version 2	Metals Ref	Grass Roo	Private	0	CR	1
O111	Version 2	Metals Ref	Modernizat	Private	0	CR	3
O112	Version 2	Metals Ref	Modernizat	Private	0	LS	4
O113	Version 2	Metals Ref	Modernizat	Private	100	CR	4
O114	Version 2	Chemical M	Add-on	Private	100	LS	4
O115	Version 2	Chemical M	Grass Roo	Private	100	CR	1
O116	Version 2	Chemical M	Grass Roo	Private	0	LS	4
O117	Version 2	Chemical M	Modernizat	Private	0	CR	3
O119	Version 2	Maintenan	Grass Roo	Public	0	LS	4
O120	Version 2	Lowrise Of	Grass Roo	Public	0	LS	4
O121	Version 2	Lowrise Of	Grass Roo	Public	0	LS	4
O122	Version 2	Pharmaceu	Modernizat	Private	60	GP	1
O123	Version 2	Pharmaceu	Modernizat	Private	0	GP	3
O124	Version 2	Pharmaceu	Grass Roo	Private	0	LS	4
O125	Version 2	Pharmaceu	Modernizat	Private	100	CR	3
O126	Version 2	Pharmaceu	Modernizat	Private	0	LS	4
O127	Version 2	Chemical M	Add-on	Private	0	CR	4
O128	Version 2	Pharmaceu	Grass Roo	Private	0	LS	4
O129	Version 2	Electrical ((	Add-on	Public	100	CR	1
O130	Version 2	Electrical ((	Add-on	Public	100	CR	1
O131	Version 2	Electrical ((	Modernizat	Public	0	LS	4
O132	Version 2	Electrical ((	Modernizat	Public	100	CR	1

conschd	consafe	Inc Indx	crftwkhr	recrdinj	lstwkdc	RIR	LWCIR
4	4	0	64200	1	0	3.115265	0
4	4	0	61168	0	0	0	0
3	1	3	604900	8	0	2.645065	0
4	4	0	60000	1	1	3.333333	3.333333
4	4	0	159968	3	0	3.75075	0
4	4	0	96344	1	0	2.075895	0
4	4	0	67066	0	0	0	0
4	4	0	320000	6	0	3.75	0
4	4	0	-999	-999	-999	200000	200000
4	4	1	640300	6	0	1.874122	0
1	1	3	587000	6	0	2.044293	0
1	1	3	3595212	103	9	5.729843	0.500666
1	1	3	188016	2	-999	2.127479	-1062.68
1	1	3	102100	1	0	1.958864	0
1	1	3	276710	3	0	2.168335	0
1	1	3	51000	1	0	3.921569	0
1	1	3	318000	1	0	0.628931	0
1	1	3	1850000	12	3	1.297297	0.324324
4	4	0	43000	0	0	0	0
1	1	3	133292	7	1	10.50326	1.500465
3	3	6	579190	32	2	11.04991	0.69062
4	4	0	174349	14	1	16.05974	1.147124
4	4	0	-888	-888	-888	200000	200000
1	1	2	88400	1	1	2.262443	2.262443
1	1	3	550000	4	0	1.454545	0
4	4	0	455000	3	1	1.318681	0.43956
4	3	4	196000	0	0	0	0
2	4	1	40000	0	0	0	0
2	4	1	60000	1	1	3.333333	3.333333
2	4	1	72254	0	0	0	0
1	1	3	47000	1	0	4.255319	0
3	3	6	120000	1	0	1.666667	0
4	4	0	1110000	57	6	10.27027	1.081081
3	3	6	900000	34	4	7.555556	0.888889
4	1	1	1000000	63	9	12.6	1.8
4	4	0	100000	0	0	0	0
3	4	2	250000	2	0	1.6	0
1	1	3	542260	8	1	2.950614	0.368827
1	4	2	29560	1	1	6.7659	6.7659
4	4	0	-888	-888	-888	200000	200000
1	4	2	49108	2	0	8.145312	0

q_23	cli_id_c	prbudget	projcost	budcscon	actcscon	Cost Grth	plncon_s
2	O88	6945000	7274000	2869000	3180000	0.1084	4/22/95
2	O89	4928000	5127000	1685000	1864000	0.106231	5/7/94
1	O90	65685000	65674000	40964000	37300000	-0.08944	10/1/93
2	O91	10100000	9300000	3278000	2818000	-0.14033	10/1/95
1	O92	8000000	9840000	1731400	3551000	1.050941	5/3/93
2	O93	10888000	11511000	5116000	5943000	0.16165	3/13/95
1	O94	9200000	8614000	2144000	1922000	-0.10354	5/1/95
2	O95	30000000	32700000	4700000	8000000	0.702128	1/24/95
1	O96	7200000	6650000	1283000	1789000	0.394388	2/15/95
1	O97	70000000	70000000	-999	-999	0	9/1/92
1	O98	58700000	54900000	-999	-999	0	9/9/09
1	O99	5.15E+08	5.15E+08	-999	-999	0	9/9/09
1	O103	23100000	22500000	11480000	12665000	0.103223	2/13/95
2	O104	9600000	9417000	8493000	8069000	-0.04992	5/15/95
1	O105	44700000	36000000	26049000	20489000	-0.21344	2/10/96
1	O106	7000000	6500000	5125000	4846000	-0.05444	9/15/95
1	O107	29000000	29200000	18630000	20289000	0.08905	10/1/95
1	O108	1.48E+08	1.45E+08	94491000	94154000	-0.00357	11/1/93
1	O109	6700000	5800000	3540000	3100000	-0.12429	6/29/96
1	O110	20500000	22400000	6391937	7360572	0.15154	3/15/95
1	O111	64800000	66230000	28640000	29229000	0.020566	3/3/95
2	O112	77600000	75005000	27605000	24630000	-0.10777	6/1/92
2	O113	37400000	46204000	14926000	22000000	0.473938	12/1/92
2	O114	18287000	17882000	7353000	8207000	0.116143	10/1/94
1	O115	81800000	66400000	37500000	30100000	-0.19733	2/1/96
1	O116	24900000	32819000	12718000	16898000	0.328668	3/1/95
1	O117	17750000	14900000	9900000	8150000	-0.17677	11/15/95
2	O119	4060000	6282000	4800000	6022000	0.254583	2/15/90
2	O120	9000000	8415000	9000000	8415000	-0.065	9/9/09
2	O121	7200000	6955400	-888	-888	0	8/8/08
2	O122	6475000	6475000	2600000	3100000	0.192308	3/8/96
1	O123	7000000	6500000	5575000	5210000	-0.06547	4/15/96
1	O124	1.29E+08	1.33E+08	74231000	79808000	0.07513	7/1/92
2	O125	53500000	54900000	46400000	47400000	0.021552	12/1/94
1	O126	1.67E+08	1.61E+08	95000000	90000000	-0.05263	1/1/93
2	O127	14550000	15399000	7435000	7854000	0.056355	4/1/95
2	O128	27800000	28600000	24500000	24100000	-0.01633	8/1/95
2	O129	54000000	59300000	36354000	46975000	0.292155	5/23/94
2	O130	5640000	5891000	2301000	2413000	0.048674	10/7/94
2	O131	50982000	56238000	9387000	14890000	0.586236	2/1/94
2	O132	7066000	6671000	2941000	2740000	-0.06834	2/10/96

plncon_f	actcon_s	actcon_f	Scd Grth
6/6/95	4/22/95	6/6/95	0.00
7/1/94	5/7/94	7/1/94	0.00
5/30/96	2/1/94	6/30/96	-0.09
4/29/96	10/1/95	4/29/96	0.00
7/1/94	5/3/93	7/11/94	0.02
12/15/95	3/20/95	4/12/96	0.40
12/21/95	5/15/95	12/31/95	-0.02
12/28/95	12/19/94	2/9/96	0.23
12/29/95	4/10/95	3/28/96	0.11
12/31/93	9/1/92	12/31/93	0.00
9/9/09	9/9/09	9/9/09	#DIV/0!
9/9/09	9/9/09	9/9/09	#DIV/0!
2/29/96	1/27/95	6/22/96	0.34
7/30/96	5/1/95	7/30/96	0.03
7/23/96	2/10/96	9/1/96	0.24
8/6/96	9/15/95	1/31/97	0.55
4/17/96	10/1/95	4/17/96	0.00
3/1/94	11/1/93	4/1/94	0.26
12/19/96	6/19/96	1/23/97	0.26
3/15/96	11/15/94	8/11/95	-0.27
3/31/97	3/13/95	9/23/96	-0.26
2/16/94	6/1/92	2/16/94	0.00
2/1/94	9/1/93	5/1/94	-0.43
11/30/95	10/1/94	11/30/95	0.00
3/1/97	1/15/96	2/15/97	0.01
3/30/96	5/1/95	5/30/96	0.00
8/15/96	12/15/95	8/15/96	-0.11
4/15/91	7/30/90	11/22/91	0.13
9/9/09	9/9/09	9/9/09	#DIV/0!
8/8/08	9/30/91	11/4/92	#DIV/0!
9/19/96	3/15/96	8/31/96	-0.13
10/15/96	4/15/96	9/15/96	-0.16
10/1/95	7/1/92	4/30/96	0.18
7/1/96	12/1/94	9/1/96	0.11
8/1/94	1/1/93	2/1/96	0.95
4/1/96	2/1/95	1/1/96	-0.09
2/28/96	8/1/95	4/25/96	0.27
9/30/95	9/23/94	12/14/95	-0.10
9/30/96	10/7/94	11/24/95	-0.43
4/30/94	10/29/94	3/12/95	0.52
3/23/96	2/10/96	3/23/96	0.00

cii_id_a	version	type	char	publpriv	cii_cntr	cnsttype	cost_inc
O133	Version 2	Metals Ref	Grass Roo	Private	0	CR	4
O134	Version 2	Automotive	Add-on	Private	0	LS	4
O135	Version 2	Automotive	Add-on	Private	35	LS	4
O136	Version 2	Foods	Grass Roo	Private	0	LS	4
O137	Version 2	Lowrise Of	Modernizat	Private	0	LS	4
O138	Version 2	Chemical M	Add-on	Private	100	UP	4
O139	Version 2	Chemical M	Grass Roo	Private	0	LS	4
O140	Version 2	Chemical M	Modernizat	Private	0	LS	4
O141	Version 2	Metals Ref	Add-on	Private	0	GP	4
O142	Version 2	Chemical M	Modernizat	Private	0	UP	4
O143	Version 2	Chemical M	Grass Roo	Private	0	CR	1
O144	Version 2	Water/Was	Grass Roo	Public	0	LS	4
O145	Version 2	Lowrise Of	Add-on	Public	0	LS	4
O146	Version 2	Oil Refining	Add-on	Private	100	CR	1
O147	Version 2	Oil Refining	Add-on	Private	100	CR	3
O148	Version 2	Oil Refining	Add-on	Private	100	CR	1
O149	Version 2	Electrical ((	Modernizat	Public	25	LS	1
O150	Version 2	Pulp and P	Add-on	Private	100	CR	3
O151	Version 2	Pulp and P	Modernizat	Private	0	CR	4
O152	Version 2	Pulp and P	Add-on	Private	0	LS	4
O153	Version 2	Pulp and P	Grass Roo	Private	0	LS	4
O154	Version 2	Pulp and P	Add-on	Private	0	LS	4
O155	Version 2	Electrical ((	Add-on	Private	100	LS	4
O156	Version 2	Water/Was	Modernizat	Private	100	CR	4
O157	Version 2	Foods	Modernizat	Private	0	GP	4
O158	Version 2	Warehouse	Add-on	Private	0	LS	4
O159	Version 2	Foods	Modernizat	Private	0	LS	4
O160	Version 2	Consumer	Add-on	Private	0	CR	4
O161	Version 2	Foods	Add-on	Private	100	CR	4
O162	Version 2	Consumer	Modernizat	Private	95	CR	4
O163	Version 2	Consumer	Add-on	Private	0	CR	4
O164	Version 2	Chemical M	Modernizat	Private	100	CR	4
O166	Version 2	Lowrise Of	Grass Roo	Private	0	LS	4
O167	Version 2	Pharmaceu	Grass Roo	Private	100	CR	4
O168	Version 2	Chemical M	Grass Roo	Private	100	CR	1
O169	Version 2	Chemical M	Grass Roo	Private	100	CR	1
O171	Version 2	Chemical M	Add-on	Private	0	LS	4
O172	Version 2	Oil Refining	Modernizat	Private	0	CR	3
O173	Version 2	Oil Refining	Add-on	Private	0	CR	4
O174	Version 2	Oil Refining	Add-on	Private	0	LS	4
O175	Version 2	Water/Was	Grass Roo	Private	100	CR	4

schd_inc	safe_inc	Inc Indx	crftwkhr	recrdinj	lstwkdc	RIR	LWCIR
4	4	0	297437	3	3	2.017234	2.017234
4	4	0	-888	1	1	-225.225	-225.225
4	4	0	375700	2	0	1.064679	0
4	4	0	521000	0	0	0	0
4	4	0	112000	0	0	0	0
4	4	0	33110	-888	-888	-5363.94	-5363.94
4	4	0	500000	2	0	0.8	0
4	4	0	194000	0	0	0	0
4	4	0	-888	-888	-888	200000	200000
4	4	0	50000	0	0	0	0
1	1	3	500000	2	0	0.8	0
4	4	0	-888	-888	-888	200000	200000
2	4	1	-888	0	0	0	0
1	1	3	2783000	14	0	1.006109	0
3	2	5	870000	12	2	2.758621	0.45977
1	2	3	336000	0	0	0	0
3	3	5	30000	0	0	0	0
3	3	6	73123	0	0	0	0
4	4	0	80713	0	0	0	0
4	4	0	27649	2	0	14.46707	0
4	4	0	103100	1	0	1.939864	0
4	4	0	24043	1	0	8.318429	0
3	4	2	1200000	5	2	0.833333	0.333333
4	4	0	38830	0	0	0	0
4	4	0	76000	0	0	0	0
4	4	0	184000	0	0	0	0
4	4	0	936093	23	2	4.914042	0.427308
4	4	0	34980	0	0	0	0
4	4	0	621000	10	0	3.220612	0
4	4	0	38000	0	0	0	0
4	4	0	-888	0	0	0	0
4	4	0	133366	0	0	0	0
4	4	0	98850	0	0	0	0
4	4	0	-888	-888	-888	200000	200000
1	1	3	96000	2	0	4.166667	0
4	4	1	617300	13	0	4.21189	0
4	4	0	-888	-888	-888	200000	200000
3	1	5	-999	-999	-999	200000	200000
4	1	1	-888	-888	-888	200000	200000
4	1	1	3348553	29	4	1.732091	0.238909
4	4	0	81415	2	0	4.9131	0

q_23	cli_id_c	prbudget	projcost	budcscon	actcscon	Cost Grth	plncon_s
2	O133	52650000	52900000	16792000	18546000	0.104455	10/1/95
2	O134	19850000	26250000	18000000	22000000	0.222222	12/1/96
2	O135	55600000	55400000	36030000	34280000	-0.04857	10/1/95
1	O136	58800000	57200000	39567620	42375430	0.070962	4/1/94
1	O137	16066600	10845700	10599600	6078700	-0.42652	2/1/95
2	O138	3900000	4800000	1091680	2008118	0.839475	8/15/95
7	O139	73000000	67600000	29100000	27400000	-0.05842	8/1/95
2	O140	21600000	21500000	7400000	7250000	-0.02027	10/1/95
2	O141	11100000	10740000	-888	-888	0	5/17/96
2	O142	4650000	4812000	1959000	2294000	0.171006	8/8/08
1	O143	67200000	56640000	22200000	17900000	-0.19369	5/1/95
2	O144	21000000	19482514	9688000	9387000	-0.03107	9/29/88
2	O145	6360000	6150806	5600000	5553877	-0.00824	3/30/94
1	O146	2.31E+08	1.78E+08	-888	-888	0	11/1/93
1	O147	1.88E+08	1.87E+08	88854000	98570000	0.109348	2/10/93
1	O148	48800000	43000000	27600000	22400000	-0.18841	3/1/95
2	O149	10976000	10968000	6888000	5436000	-0.2108	6/26/95
2	O150	5663000	8323000	2126000	4505000	1.119003	3/22/96
2	O151	7500000	7949000	3200000	3549000	0.109063	8/8/08
2	O152	15185000	14000000	4685000	3418000	-0.27044	5/15/95
2	O153	11559000	11572000	3548000	3930000	0.107666	10/17/94
2	O154	6000000	5400000	4251000	3750000	-0.11785	5/24/96
1	O155	1.43E+08	1.44E+08	-888	-888	0	10/15/95
1	O156	26250000	23674000	16137000	-888	-1.00006	3/1/94
1	O157	22800000	22800000	8536900	8320000	-0.02541	10/28/96
1	O158	25733000	25733000	10232300	10955723	0.0707	3/9/95
1	O159	76500000	82404000	34937000	40291000	0.153247	11/30/94
1	O160	7800000	8700000	2057000	1831000	-0.10987	3/15/96
2	O161	79000000	72400000	30900000	34600000	0.119741	11/1/95
1	O162	6100000	6500000	-888	-888	0	10/7/96
2	O163	1700000	1550000	727000	592000	-0.18569	4/1/96
1	O164	9900000	9730000	3998000	4930000	0.233117	5/3/96
2	O166	11750000	12840000	11125000	12007000	0.079281	11/15/95
2	O167	28620000	25420000	11895000	11805000	-0.00757	1/15/94
2	O168	17001000	13086000	8100000	5936000	-0.26716	5/1/95
8	O169	1.25E+08	1.04E+08	70388000	54497000	-0.22576	9/1/94
8	O171	7844000	-888	3312000	-888	-1.00027	3/10/97
1	O172	5025000	5300000	-888	-888	0	1/1/96
8	O173	24000000	26000000	13524000	15300000	0.131322	3/1/96
1	O174	1.73E+08	2.31E+08	78882000	1.42E+08	0.803238	9/15/95
1	O175	7200000	7094000	2192000	2037000	-0.07071	4/19/95

plncon_f	actcon_s	actcon_f	Scd Grth
5/1/96	11/1/95	7/1/96	0.14
7/1/97	12/1/96	7/1/97	0.00
7/1/97	12/1/95	7/1/97	-0.10
7/1/96	5/1/94	3/15/97	0.28
2/1/96	3/1/95	1/1/96	-0.16
5/15/96	9/15/95	5/15/96	-0.11
11/30/96	8/1/95	12/10/96	0.02
9/1/96	10/1/95	9/30/96	0.09
10/25/96	4/29/96	11/15/96	0.24
6/30/96	8/8/08	6/30/96	0.00
4/1/96	3/15/95	4/1/96	0.14
1/10/91	11/9/88	5/9/91	0.09
12/19/95	3/30/94	3/21/96	0.15
10/31/95	11/1/93	8/14/95	-0.11
6/1/94	3/15/93	6/1/94	-0.07
8/1/96	3/1/95	7/13/96	-0.04
8/23/96	6/26/95	8/23/96	0.00
10/7/96	5/1/96	4/18/97	0.77
8/8/08	5/6/96	2/27/97	#DIV/0!
12/15/95	5/15/95	3/15/96	0.43
2/6/96	10/17/94	1/31/96	-0.01
11/4/96	5/24/96	11/4/96	0.00
12/15/96	10/15/95	1/15/97	0.07
6/1/96	2/1/94	1/1/96	-0.15
4/18/97	10/28/96	4/18/97	0.00
4/28/96	3/9/95	4/28/96	0.00
2/1/97	11/30/94	4/1/97	0.07
10/15/96	3/15/96	10/15/96	0.00
1/1/97	11/1/95	1/1/97	0.00
4/11/97	10/7/96	4/11/97	0.00
6/17/96	4/15/96	7/22/96	0.27
12/13/96	3/18/96	4/11/97	0.74
12/15/96	10/15/95	4/15/97	0.38
1/6/95	1/15/94	12/7/94	-0.08
12/1/95	5/15/95	11/16/95	-0.14
11/1/95	8/30/94	10/31/95	0.00
6/20/97	3/24/97	8/8/08	-318.35
5/1/96	1/1/96	6/30/96	0.50
12/1/96	3/1/96	12/15/96	0.05
12/17/96	9/15/95	3/17/97	0.20
12/5/95	4/10/95	6/28/96	0.93

cil_id_a	version	type	char	publpriv	cil_cntr	cnsttype	cost_inc
O176	Version 2	Chemical M	Add-on	Private	0	CR	4
O177	Version 2	Chemical M	Modernizat	Private	100	UP	2
O178	Version 2	Consumer	Modernizat	Private	100	UP	4
O179	Version 2	Water/Was	Grass Roo	Private	0	CR	4
O180	Version 2	Electrical D	Modernizat	Private	0	LS	4
O182	Version 2	Oil Refining	Add-on	Private	0	LS	4
O184	Version 2	School	Grass Roo	Public	0	LS	4
O185	Version 2	School	Grass Roo	Public	0	LS	4
O186	Version 2	School	Modernizat	Public	0	LS	4
O187	Version 2	School	Grass Roo	Public	0	LS	4
O188	Version 2	Chemical M	Add-on	Private	100	CR	1
O189	Version 2	Oil Refining	Add-on	Private	0	CR	1
O190	Version 2	Maintenanc	Add-on	Public	0	LS	4
O191	Version 2	Highrise O	Grass Roo	Public	0	LS	4
O192	Version 2	Laboratory	Grass Roo	Public	0	LS	4
O193	Version 2	Restaurant	Grass Roo	Public	0	LS	4
O194	Version 2	Dormatory/	Grass Roo	Public	0	LS	4
O195	Version 2	Dormatory/	Grass Roo	Public	0	LS	4
O196	Version 2	Chemical M	Add-on	Private	100	CR	3

schd_inc	safe_inc	Inc Indx	crftwkhr	recrdinj	lstwkdc	RIR	LWCIR
4	1	1	581000	8	0	2.753873	0
2	1	3	-888	-888	-888	200000	200000
4	4	0	98000	0	0	0	0
4	1	1	148360	5	1	6.740361	1.348072
4	4	0	-888	0	0	0	0
4	4	0	-888	0	0	0	0
4	4	0	-888	-888	-888	200000	200000
4	4	0	-888	-888	-888	200000	200000
4	4	0	-888	-888	-888	200000	200000
4	4	0	-888	-888	-888	200000	200000
1	1	3	660000	4	0	1.212121	0
4	4	1	45000	0	0	0	0
4	4	0	-888	-888	-888	200000	200000
4	4	0	-888	-888	-888	200000	200000
4	4	0	-888	-888	-888	200000	200000
4	4	0	-888	-888	-888	200000	200000
4	4	0	-888	-888	-888	200000	200000
4	4	0	-888	-888	-888	200000	200000
3	4	4	317725	-888	0	-558.974	0

q_23	cil_id_c	prbudget	projcost	budcscon	actcscon	Cost Grth	plncon_s
1	O176	57800000	51422000	13784320	13832000	0.003459	6/15/94
1	O177	82746000	1.07E+08	39796661	54123000	0.359988	8/8/08
1	O178	21000000	21500000	5800000	6280000	0.082759	2/1/96
1	O179	23500000	22770000	13547000	10755000	-0.2061	2/5/95
2	O180	5125000	5549000	-888	4100000	-4618.12	8/8/08
2	O182	18000000	16000000	11800000	9780000	-0.17119	8/8/08
2	O184	23054000	22370000	14688000	14771000	0.005651	1/19/95
2	O185	13200000	13171000	9910000	11450000	0.155399	9/15/95
2	O186	23600000	24735000	19758000	22315000	0.129416	2/1/96
2	O187	18062000	18727000	15611000	15906000	0.018897	8/8/08
1	O188	42120000	47230000	12112000	14778000	0.220112	10/24/95
2	O189	7500000	7975000	2000000	3325000	0.6625	3/1/94
2	O190	22260000	16580000	21000000	15677000	-0.25348	6/30/91
2	O191	75000000	78170000	69700000	73025000	0.047704	1/3/95
2	O192	28565000	29153000	26455000	27168000	0.026951	3/21/94
2	O193	7156000	7494000	6542000	6774000	0.035463	9/20/93
1	O194	2.87E+08	2.72E+08	2.75E+08	2.6E+08	-0.05472	1/15/95
8	O195	10900000	8547000	8668000	8227000	-0.05088	10/30/94
2	O196	50400000	47500000	-888	-888	0	8/8/08

plncon_f	actcon_s	actcon_f	Scd Grth
11/15/95	6/15/94	11/15/95	0.00
8/8/08	3/15/95	7/15/96	#DIV/0!
8/1/96	5/1/96	4/1/97	0.84
2/5/96	3/13/95	4/18/96	0.10
8/8/08	1/15/93	12/15/96	#DIV/0!
8/8/08	10/12/91	11/15/92	#DIV/0!
6/17/96	1/19/95	6/30/96	0.03
3/31/97	3/1/95	4/16/97	0.38
8/1/97	2/5/96	9/1/97	0.05
8/8/08	2/21/96	7/31/97	#DIV/0!
7/24/96	12/6/95	10/26/96	0.19
4/1/94	10/1/94	11/1/94	0.00
7/30/94	6/14/91	12/21/93	-0.18
9/9/09	1/25/95	2/17/97	-1.02
2/22/96	3/22/94	4/6/96	0.06
12/20/94	8/30/93	5/3/95	0.34
9/30/96	2/28/95	9/30/96	-0.07
12/30/95	10/26/95	11/30/96	-0.06
8/8/08	8/8/08	8/8/08	#DIV/0!

Appendix B: CII Questionnaire (Owner Version 2.0)

The data collected by this form begins the second round of data collection for CII's benchmarking and metrics system. The data will be used to establish performance norms, to identify trends, and to correlate execution of project management processes to project outcomes. It will form part of a permanent database. Through such correlation across many companies and projects, opportunities for improving your company's project performance will be identified. CII will not analyze performance of individual companies, however. Each company will be provided the means to compare itself to the benchmarks. Therefore, it is important that you retain a copy of this questionnaire for your records. **All data will be held in strict confidence.**

When you have completed the questionnaire, please return it to your Company's Data Liaison by **May 1, 1997.**

The next 2 pages contain definitions for project phases. Please pay particular attention to the start and stop points which have been highlighted. All project costs should be given in U.S. dollars. If you need further assistance in interpreting the intent of a question, please call Ned Givens or Kirk Morrow of CII at (512) 471-4319 (E-mail: tkmorrow@mail.utexas.edu). Remember, conformance to the instructions and phase definitions is crucial for establishing reliable benchmarks.

Your company data liaison has been provided with a list of projects which were submitted by your company during the previous data collection effort. In order to maintain the integrity of the database, please ensure that projects which have been submitted previously are not reported again.

If the information required to answer a given question is not available, please write "UNK" (unknown) in the space provided. If the information requested does not apply to this project, please write "NA" (not applicable) in the space provided. However, keep in mind that too many "unknowns" or "not applicables" could render the project unusable for analysis.

This form should be completed under the direction of the project manager. The project manager should consult with colleagues who worked on the project. We urge that you carefully review the phase table on the next 2 pages before attempting to provide the requested information.

Definition is provided in the attached glossary for words and phrases that are both italicized and underlined.

Project Phase Table

Project Phase	**START/STOP**	Typical Activities & Products	Typical Cost Elements
Pre-Project Planning Typical Participants: • Owner personnel • Planning Consultants • Constructability Consultant • Alliance / Partner	**Start: Defined Business Need that requires facilities** **Stop: Total Project Budget Authorized**	• Options Analysis • Life-cycle Cost Analysis • Project Execution Plan • Appropriation Submittal Pkg • P&IDs and Site Layout • Project Scoping • Procurement Plan • Arch. Rendering	• Owner Planning team personnel expenses • Consultant fees & expenses • Environmental Permitting costs • Project Manager / Construction Manager fees • Licensor Costs
Detail Design Typical Participants: • Owner personnel • Design Contractor • Constructability Expert • Alliance / Partner	**Start: Design Basis** **Stop: Release of all approved drawings and specs for construction (or last package for fast-track)**	• Drawing & spec preparation • Bill of material preparation • Procurement Status • Sequence of operations • Technical Review • Definitive Cost Estimate	• Owner project management personnel • Designer fees • Project Manager / Construction Manager fees
Demolition / Abatement (see note below) Typical Participants: • Owner personnel • General Contractor • Demolition Contractor • Remediation / Abatement Contractor	**Start: Mobilization for demolition** **Stop: Completion of demolition**	• Remove existing facility or portion of facility to allow construction or renovation to proceed • Perform cleanup or abatement / remediation	• Owner project management personnel • Project Manager / Construction Manager fees • General Contractor and/or Demolition specialist charges • Abatement / remediation contractor charges

Note: The demolition / abatement phase should be reported when the demolition / abatement work is a separate schedule activity (potentially paralleling the design and procurement phases) in preparation for new construction. Do not use the demolition / abatement phase if the work is integral with modernization or addition activities.

Project Phase Table (Cont.)

Project Phase	START/STOP	Typical Activities & Products	Typical Cost Elements
Procurement Typical Participants: • Owner personnel • Design Contractor • Alliance / Partner	**Start: Procurement Plan for Engineered Equipment** **Stop: All engineered equipment has been delivered to site**	• Vendor Qualification • Vendor Inquiries • Bid Analysis • Purchasing • Expediting • Engineered Equipment • Transportation • Vendor QA/QC	• Owner project management personnel • Project Manager / Construction Manager fees • Procurement & Expediting personnel • Engineered Equipment • Transportation • Shop QA / QC
Construction Typical Participants: • Owner personnel • Design Contractor (Inspection) • Construction Contractor and its subcontractors	**Start: Beginning of continuous substantial construction activity** **Stop: *Mechanical Completion***	• Set up trailers • Site preparation • Procurement of bulks • Issue Subcontracts • Construction plan for Methods/Sequencing • Build Facility & Install Engineered Equipment • Complete Punchlist • Demobilize construction equipment • Warehousing	• Owner project management personnel • Project Manager / Construction Manager fees • Building permits • Inspection QA/QC • Construction labor, equipment & supplies • Bulk materials • Construction equipment • Contractor management personnel • Warranties
Start-up / Commissioning Note: Does not usually apply to infrastructure or building type projects Typical Participants: • Owner personnel • Design Contractor • Construction Contractor • Training Consultant • Equipment Vendors	**Start: *Mechanical Completion*** **Stop: Custody transfer to user/operator (steady state operation)**	• Testing Systems • Training Operators • Documenting Results • Introduce Feedstocks and obtain first Product • Hand-off to user/operator • Operating System • Functional Facility • Warranty Work	• Owner project management personnel • Project Manager / Construction Manager fees • Consultant fees & expenses • Operator training expenses • Wasted feedstocks • Vendor fees

1. Your Company: ____

2. Your Project I.D. _________________________ (You may use any reference to protect the project's identity. The purpose of this I.D. is to help you and CII personnel identify the questionnaire correctly if clarification of data is needed and to prevent duplicate project entries.)

3. Project Location: Domestic ___________________________, USA
State
International ________________________
Country

4. Contact Person (name of the person filling out this form): ___________________

5. Contact Phone No.(   ) ______________ 6. Contact Fax No. (   ) ______

7. Principal Type of Project (Check only one. If you feel the project does not have a principal type, but is an even mixture of two or more of those listed, please attach a short description of the project. If the project type does not appear in the list, please describe in the space next to "Other."):

Industrial	Infrastructure	Buildings
_____Electrical (Generating)	_____Electrical Distribution	__Lowrise Office
_____Oil Exploration/Production	__________________Highway	
_____Highrise Office		
_____Oil Refining	_____Navigation	__Warehouse
_____Pulp and Paper	_____Flood Control	__Hospital
_____Chemical Mfg.	_____Rail	__Laboratory
_____Environmental	_____Water/Wastewater	__School
_____Pharmaceuticals Mfg.	_____ Airport	__Prison
_____Metals Refining/Processing	__________________Tunneling	
_____Consumer Products Mfg.	_____Mining	__Parking Garage
_____Natural Gas Processing		___Retail
_____Automotive Mfg.		
_____Foods		

_____Other (Please describe)______________________________

____

8. This project was (check only one): Grass Roots_____ Modernization _____
Addition _____

Grass roots - a new facility from the foundations and up. A project requiring demolition of an existing facility before new construction begins is also classified as grass roots.

Modernization - a facility for which a substantial amount of the equipment, structure, or other components is replaced or modified, and which may expand capacity and/or improve the process or facility.

Addition - a new addition that ties in to an existing facility, often intended to expand capacity.

_____ Other (Please describe)________________________________

____

9. Achieving Design Basis. Please indicate in the following table the product or function of the completed facility, the unit of measure which best relates the product or function capacity of the completed facility, the planned capacity of the facility at the start of detail design, and the capacity achieved by the completed facility.

For process facilities, the measure is either one of input or output as appropriate. Examples : crude oil refining unit - barrels per day throughput

For infrastructure or buildings, please include the measure that you feel is best. Please spell out this measure rather than using an abbreviation.

If the product produced or function provided by this facility is of a confidential nature, please write "Confidential" in the first column and provide the other data.

If you are unable to furnish a measure or units, please write "NA" (not applicable) in the "Product or Function" field and go to question 10.

Product or Function	Unit of Measure	Planned Start-up Capacity	Achieved Start-up Capacity	Planned Final Capacity	Achieved Final Capacity

9a. Please indicate the method of ***acceptance testing*** used on this project.

_____ No Assessment

_____ Demonstrated operations at achieved level

_____ Formal documented acceptance test over a meaningful period of time

9b. Please indicate how the achieved capacity of the completed facility compares against expectations documented in the project execution plan. If the achieved capacity is much worse or much better than expected, please briefly comment on the primary cause of the deviation.

_____ Much worse than expected Why?

____

_____ Worse than expected

____

_____ As expected

_____ Better than expected

_____ Much better than expected Why?

____

____

____

10. **Project Participants**. Please list the companies, including your company, that helped execute this project, but do not list any subcontractors. Indicate the function(s) each company performed and the approximate percent of that function to the nearest 10%. For each function, indicate the principle form of remuneration in use at the completion of the work. Please indicate if each participant was an alliance partner and if their contract contained incentives.

Please use the following codes to identify the **Function** performed by each project participant.

PPP	Pre-Project Planner	DM	Demolition/Abatement Contractor
PPC	Pre-Project Planning Consultant	GC	General Contractor
D	Designer	PC	Prime Contractor
PE	Procurement - Equipment	PM	Project Manager
PB	Procurement - Bulks	CM	Construction Manager

Percent of Function refers to the percent of the overall function contributed by the company listed. Estimate to the nearest 10 percent.

Type of Remuneration refers to the overall method of payment. Unit price refers to a price for in place units of work and does not refer to hourly charges for skill categories or time card mark-ups. Hourly rate payment schedules should be categorized as cost reimbursable. Please use the following codes to identify remuneration type. Record the form of remuneration for your own company's contribution, if any, as "I" (In House).

LS	Lump Sum	GP	Guaranteed Maximum Price
UP	Unit Price	I	In-house
CR	Cost Reimbursable/Target Price (Including Incentives)		

An ***<u>Alliance Partner</u>*** is a company with whom your company has a long-term formal strategic agreement that ordinarily covers multiple projects. Circle "Y" to indicate that a company was an alliance partner or circle "N" if the company was not an alliance partner.

If **Contract Incentives** were utilized, please indicate whether those incentives were positive (a financial incentive for attaining an objective),

negative (a financial disincentive for failure to achieve an objective), or both. Circle "+" to indicate a positive incentive and circle "-" to indicate a negative incentive.

Company Name	Function	Approx. Percent of Function (Nearest 10%)	Type of Remun. (Contract End)	Was this company an alliance partner? (Yes/No)		Contract Incentives (circle as many as apply)							
						Cost		Schedule		Safety		Quality	
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-
				Y	N	+	-	+	-	+	-	+	-

11a. *Total Project Budget*

- The total project budget amount should correspond to the estimate at the start of detail design including ***contingency***.
- The total project budget amount should include all planned expenses from pre-project planning through startup or to a "ready for use" condition, excluding the ***cost of land***.
- State the project budget in U.S. dollars to the nearest $1000. (You may use a "k" to indicate thousands in lieu of "...,000".)

$________________________

11b. How much ***contingency*** does this budget contain? (to the nearest $1000. You may use a "k" to indicate thousands in lieu of "...,000".)

$________________________

12. *Total Actual Project Cost*:

- The total actual project cost should include all actual project costs from pre-project planning through startup or to a "ready for use" condition, excluding the cost of land.
- Actual costs should correspond to those that were part of the budget. For example, if the budget included specific amounts for in-house personnel, then actual cost should include the actual amounts expended during the project for their salaries, overhead, travel, etc.
- State the project cost in U.S. dollars to the nearest $1000. (You may use a "k" to indicate thousands in lieu of "...,000".)

$________________________

13. Please indicate the budgeted and actual costs by project phase

- Phase budget amounts should correspond to the estimate at the start of detail design.
- Refer to the table on pages 2 and 3 for phase definitions and typical cost elements.
- State the phase costs in U.S. dollars to the nearest $1000. (You may use a "k" to indicate thousands in lieu of "...,000".)
- Include the cost of bulk materials in construction and the cost of engineered equipment in procurement.
- If this project did not involve Demolition/Abatement or Startup please write "NA" for those phases.
- The sum of phase budgets should equal the Total Project Budget and the sum of actual phase costs should equal Total Actual Project Cost from questions 11 & 12 above.

Project Phase	Phase Budget (Including Contingency)	Amount of Contingency in Budget	Actual Phase Cost
Pre-Project Planning	$	$	$
Detail Design	$	$	$
Procurement	$	$	$
Demolition/Abatement	$	$	$
Construction	$	$	$
Startup	$	$	$
Totals	$	$	$

14. Planned and Actual Project Schedule

- The dates for the planned schedule should be those in effect at the start of detail design. If you cannot provide an exact day for either the planned or actual, estimate to the nearest week in the form mm/dd/yy; for example, 1/8/96, 2/15/96, or 3/22/96.)
- Refer to the chart on pages 2 and 3 for a description of starting and stopping points for each Phase.

- If this project did not involve Demolition/Abatement or Startup please write “NA” for those phases.

Project Phase	Planned Schedule		Actual Schedule	
	Start mm / dd / yy	Stop mm / dd / yy	Start mm / dd / yy	Stop mm / dd / yy
Pre-Project Planning	/ /	/ /	/ /	/ /
Detail Design	/ /	/ /	/ /	/ /
Procurement	/ /	/ /	/ /	/ /
Demolition/Abatement	/ /	/ /	/ /	/ /
Construction	/ /	/ /	/ /	/ /
Startup	/ /	/ /	/ /	/ /

14a. What percentage of the total engineering workhours for design were completed prior to total project budget authorization? (Write "UNK" in the blank if you don't have this information)

_________ %

14b. What percentage of the total engineering workhours for design were completed prior to start of the construction phase? (Write "UNK" in the blank if you don't have this information)

_________ %

15. ***Project Development Changes*** and ***Scope Changes.*** Please record the changes to your project by phase in the table provided below. For each phase indicate the total number, the net cost impact, and the net schedule impact resulting from project development changes and scope changes. Changes may be initiated by either the owner or contractor.

Project Development Changes include those changes required to execute the original scope of work or obtain original process basis.

Scope Changes include changes in the base scope of work or process basis.

- Changes should be included in the phase in which they were initiated. Refer to the table on pages 2 and 3 to help you decide how to classify the changes by project phase. If you cannot provide the requested change information by phase, but can provide the information for the total project please indicate the totals.

- Indicate "minus" (–) in front of cost or schedule values, if the net changes produced a reduction. If no changes were initiated during a phase, write "0" in the "Total Number" columns.

- State the cost of changes in U.S. dollars to the nearest $1000 and the schedule changes to the nearest week. You may use a "k" to indicate thousands in lieu of "...,000".

Project Phase	Total Number of Project Development Changes	Total Number of Scope Changes	Net Cost Impact of Project Development Changes ($)	Net Cost Impact of Scope Changes ($)	Net Schedule Impact of Project Development Changes (weeks)	Net Schedule Impact of Scope Changes (weeks)
Design			$	$	wks	wks
Procurement			$	$	wks	wks
Demolition/Abatement			$	$	wks	wks
Construction			$	$	wks	wks
Startup			$	$	wks	wks

Totals			$	$	wks	wks

16. Field Rework

Was there a system for tracking and evaluating field rework for this project?

_____ Yes _____ No

If yes, please complete the following table. If no, proceed to question 17.

Please indicate the Direct Cost of Field Rework, the Cost of Quality Management, and the Schedule Impact of Field Rework for each category shown in the following table. If you track field rework by a few other or additional categories, please add them in the blank spaces provided. If the system used on this project does not include any of the Sources of Field Rework listed, write "NA" (not applicable) in the Direct Cost of Field Rework space. If your system used a listed Source of Field Rework, but this project had no Field Rework attributable to it, write "0" in the Direct Cost of Field Rework space. If you cannot provide the requested field rework information by Source of Field Rework, but can provide the information for the total project, please write "UNK" (unknown) in the fields adjacent to the sources of field rework and indicate the totals.

The ***direct cost of field rework*** relates to all costs needed to perform the rework itself whereas the ***cost of quality management*** includes quality assurance or quality control costs, which may identify the need to perform field rework or prevent the need for additional field rework.

Source of Field Rework	Direct Cost of Field Rework	Cost of Quality Management	Schedule Impact of Field Rework
Owner Change	$	$	Weeks
Design Error / Omission	$	$	Weeks
Designer Change	$	$	Weeks
Vendor Error / Omission	$	$	Weeks
Vendor Change	$	$	Weeks
Constructor Error / Omission	$	$	Weeks
Constructor Change	$	$	Weeks
Transportation Error	$	$	Weeks
	$	$	Weeks
	$	$	Weeks
	$	$	Weeks
	$	$	Weeks
	$	$	Weeks
	$	$	Weeks
Totals	$	$	Weeks

17. Actual Total Cost of Major Equipment

Please record the actual total cost of major equipment procured for permanent installation in this project in the space provided below.

- Include only the invoiced cost for items of major equipment. Do not include the cost of associated services such as making vendor inquiries, analyzing vendor bids, or expediting.
- State the cost of equipment in U.S. dollars to the nearest $1000. You may use a "k" to indicate thousands in lieu of "...,000". Refer to the following table to help you identify major equipment expenditures.
- If the project did not include major equipment, which is typical of many infrastructure or building projects, please write "NA."

$ ______________

General Classification	Kinds of Equipment Covered
Columns and Pressure Vessels (Code Design)	Towers, columns, reactors, unfired pressure vessels, bulk storage spheres, and unfired kilns; includes internals such as trays and packing.
Tanks (non-code design; 0-15 psig, MAW or design pressure)	Atmospheric storage tanks, bins, hoppers, and silos.
Exchangers	Heat transfer equipment: tubular exchangers, condensers, evaporators, reboilers, coolers (including fin-fan coolers and cooling towers) - excludes fired heaters.
Direct-fired Equipment	Fired heaters, furnaces, boilers, kilns, and dryers, including associated equipment such as super-heaters, air preheaters, burners, stacks, flues, draft fans and drivers, etc.
Pumps	All types of liquid pumps and drivers.
Vacuum Equipment	Mechanical vacuum pumps, ejectors, and other vacuum-producing apparatus and integral auxiliary equipment.
Turbines	
Motors	
Electricity Generation and Transmission	Major electrical items (e.g., transformers, switch gear, motor-control centers, batteries, battery chargers, and cable [15kV]).
Speed Reducers/Increasers	
Materials-Handling Equipment	Conveyers, cranes, hoists, chutes, feeders, scales and other weighing devices, packaging machines, and lift trucks.
Package Units	Integrated systems bought as a package (e.g., air dryers, refrigeration systems, ion-exchange systems, etc.).

Special Processing Equipment	Agitators, crushers, pulverizers, blenders, separators, cyclones, filters, centrifuges, mixers, dryers, extruders, and other such machinery with their drivers.

17b. Project Complexity

Place a mark anywhere on the scale below that best describes the level of complexity for this project as compared to other projects from the same industry sector. For example, if this is a heavy industrial project, how does it compare in complexity to other heavy industrial projects. Use the definitions below the scale as general guidelines.

Low Complexity — Average Complexity — High Complexity

- **Low Complexity -** Characterized by the use of no unproven technology, small number of process steps, small facility size or process capacity, previously used facility configuration or geometry, proven construction methods, etc.

- **High Complexity -** Characterized by the use of unproven technology, an unusually large number of process steps, large facility size or process capacity, new facility configuration or geometry, new construction methods, etc.

18. Workhours and Accident Data

Please record total craft workhours, the number of recordable injuries, and the number of lost workday cases separately in the spaces provided below.

- Use the U.S. Department of Labor's OSHA definitions for recordable injuries and lost workday cases among this project's craft workers. If you do not track in accordance with these definitions, write "UNK" in the recordable injuries and lost workday cases columns.

- Write "UNK" in any space for which the information is unavailable or incomplete.

- A consolidated project OSHA 200 log is the best source for the data.

Total Craft Workhours	OSHA Recordable Injuries	OSHA Lost Workday Cases

18a. How many of the craft workhours reported in the table above were "overtime" (or "premium time")? (Write "UNK" in the blank if you don't have this information)

_____ hrs

Safety Practices

Safety includes the site-specific program and efforts to create a project environment and state of consciousness which embraces the concept that all accidents are preventable and that zero accidents is an obtainable goal. If this project was accident free, check "NA" as appropriate for questions 27 through 30.

	Yes	No	
19.	___	___	This project had a written site-specific safety plan.
20.	___	___	This project had a written site-specific emergency plan.
21.	___	___	This project had a site safety supervisor.
22.	___	___	The site safety supervisor for this project was full-time.
23.	___	___	This project had a written safety incentive program for hourly craft employees.
24.	___	___	Toolbox safety meetings were required.
25.	___	___	This project required prehire substance abuse testing of contractor employees.
26.	___	___	Contractor employees were randomly screened for alcohol and drugs.

27. Substance abuse tests were conducted after an accident:

_____ Always _____ Sometimes ____ Seldom ____ Never _____ NA

28. Accidents were formally investigated:

_____ Always _____ Sometimes _____ Seldom _____ Never______ NA

29. Near-misses were formally investigated:

_____ Always ______Sometimes____ Seldom ______ Never ____NA

30. Senior management reviewed accidents:

_____ Always ______Sometimes ____ Seldom _______ Never_____ NA

31. Safety was a high priority topic at all pre-construction and construction meetings:

_____ Always _____ Sometimes _____ Seldom _____ Never

32. Safety records were a criterion for contractor/subcontractor selection:

_____ Always _____ Sometimes _____ Seldom _____ Never

33. Pre-task planning for safety was conducted by contractor foremen:

_____ Always _____ Sometimes _____ Seldom _____ Never

34. Jobsite-specific orientation was conducted for new contractor and subcontractor employees:

_____ Always _____ Sometimes _____ Seldom _____ Never

35. This question is for Contractors only.

Team Building Practices

Team Building is a process that brings together a diverse group of project participants and seeks to resolve differences, remove roadblocks and proactively build and develop the group into an aligned, focused and motivated work team that strives for a common mission and for shared goals, objectives and priorities.

36. Was a team building process used for this project? Yes _____ No ____

If yes, answer questions 36a - 36h. If no, go to question 37.

	Yes	No	
36a.	___	___	Was an independent consultant used to facilitate the team building process?
36b.	___	___	Was a team-building retreat held early in the life of the project?
36c.	___	___	Did this project have a documented team-building implementation plan?
36d.	___	___	Were objectives of the team building process documented and clearly defined?

36e. Were team building meetings held among team members throughout the project?

______ Regularly ______ Sometimes ______ Seldom ______ Never

36f. Were follow-up sessions held to integrate new team members and reinforce concepts?

______ Regularly ______ Sometimes ______ Seldom ______ Never

36g. Please indicate the project phases in which team building was used. (Check all that apply)

____ Pre-Project Planning
____ Design
____ Procurement
____ Construction
____ Startup

36h. Please indicate the parties involved in the team building process. (Check all that apply)

____ Owner
____ Designer(s)
____ Contractor(s)
____ Major Suppliers
____ Subcontractor(s)
____ Construction Manager
____ Other. If other, please specify

____

Constructability Practices

Constructability is the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives. Constructability is achieved through the effective and timely integration of construction input into planning and design as well as field operations.

37. Was Constructability implemented on this project? Yes _____ No _____

If yes, please respond to the following statements (37a-37l). If no, go to question 38.

37a. Which of the following best describes the constructability program designation for this project?

____ No designation
____ Part of standard construction management activities
____ Part of another program, such as Quality or only identified on a project level
____ Recognized on a corporate level, but may be part of another program
____ Stand-alone program on same level as Quality or Safety

37b. Which of the following best describes the constructability training of personnel for this project?

____ None
____ If any occurs, done as on-the-job training
____ Awareness seminar(s)
____ Part of standard orientation
____ Part of standard orientation; deeply ingrained in corporate culture

37c. Which of the following best describes the role of the constructability coordinator for this project?

____ Coordinator not identified
____ Part-time if identified; very limited responsibility
____ Informal full- or part-time position; responsibilities vary
____ Formal full- or part-time position; responsibilities vary
____ Full-time position; plays major project role

37d. Which of the following best describes the constructability program documentation for this project?

____ None; CII documents may be available
____ Limited reference in any manual; CII documents may be distributed or referenced

____ Project-level constructability documents exist; may be included in other corporate documents
____ Project constructability manual is available
____ Project constructability manual is thorough, widely distributed, and periodically updated

37e. Which of the following best describes the nature of project-level efforts and inputs concerning constructability for this project?

____ None
____ Reactive approach, constrained by review mentality, poor understanding of proactive benefit
____ Aware of major benefits, proactive approach
____ Proactive approach; routinely consult lessons learned
____ Aggressive, proactive approach from beginning of project; routinely consult lessons learned

37f. Which of the following best describes the implementation of constructability concepts on this project?

____ Very little concept implementation
____ Some concepts used periodically; often considered too late to be of use
____ Selected concepts applied regularly; full use, timeliness of input varies
____ All concepts consistently considered; timely implementation of feasible concepts
____ All concepts consistently considered, continuously evaluated, aggressively implemented

37g. Constructability ideas on this project were collected by: (Check as many as apply)

_____ Suggestion Box
_____ Interviews
_____ Review Meetings
_____ Questionnaire
_____ Other Methods

_____ Not Collected

37h. To what extent was a computerized constructability database utilized for this project?

_____ None
_____ Minimal
_____ Moderate
_____ Extensive

37i. Please characterize the frequency of the constructability reviews and discussions for this project.

_____ Once a Week
_____ Once a Month
_____ Once every 3 Months
_____ Once every 6 Months
_____ Once a Year or Less Frequent

37j. Please indicate the time period of the first meeting that deliberately and explicitly focused on constructability. Place a check below the appropriate period.

Pre-Project Planning			Detail Design/Procurement			Construction		
Early	Middl e	Late	Early	Middl e	Late	Early	Middl e	Late

Yes No

37k. ___ ___ Constructability was an element addressed in this project's formal written execution plan.

37l. ___ ___ Were the actual cost savings (identified cost savings less implementation cost) due to the constructability program tracked on this project?

If yes, please list? $ ________________

Pre-Project Planning Practices

Pre-Project Planning involves the process of developing sufficient strategic information with which owners can address risk and decide to commit resources to maximize the chance for a successful project. Pre-project planning is often perceived as synonymous with front-end loading, front-end planning, feasibility analysis, and conceptual planning. Please respond to the following statements using the definition provided below the scale for guidance (Questions 38a - 38d are for Contractors only.)

38e. Place a mark on the scale below that best describes the composition of the pre-project planning team.

Excellent Poor

- **Excellent** - Highly skilled and experienced members with authority; representation from business, project management, technical disciplines, and operations; able to respond to both business and project objectives.
- **Poor** - Members with a poor combination of skill or experience that lack authority; insufficient representation from business, project management, technical disciplines, and operations; unable to respond to both business and project objectives.

38f. Place a mark on the scale below that best describes the technology evaluation for this project.

Excellent Poor

- **Excellent** - Thorough and detailed identification and analysis of existing and emerging technologies for feasibility and compatibility with corporate business and operations objectives. Scale-up problems and hands-on process experience were considered.
- **Poor** - Poor or no technology evaluation.

Excellent Poor

38g. Place a mark on the scale below that best describes the evaluation of alternate siting locations.

- **Excellent** - Thorough and detailed assessment of relative strengths and weaknesses of alternate locations to meet owner requirements.

Excellent Poor

- **Poor** - Poor or no evaluation of alternate siting locations.

38h. Place a mark on the scale below that best describes the risk analysis performed for project alternatives.

- **Excellent** - Risks associated with the selected project alternatives were identified and analyzed. These analyses included financial/business, regulatory, project, and operational risk categories in order to minimize the impacts of risks on project success.
- **Poor** - Poor or no risk analysis performed for project alternatives.

The Project Definition Rating Index (PDRI) identifies and describes critical elements in a scope definition package and allows a project team to predict factors impacting project risk. It is intended to evaluate the completeness of project scope definition prior to consideration for authorization.

39. Was the Project Definition Rating Index (PDRI) utilized on this project? _____ yes _____ no

If yes, indicate the score received just prior to total project budget authorization. _________

Please attach a copy of the PDRI scoresheet and proceed to question 40.

If no, please complete the following matrix using the appropriate definition levels given below. Definition is provided for each of the pre-project planning elements on pages 4 through 11 of the glossary of terms. Indicate how well defined each element was prior to the total project budget authorization by placing a check below the appropriate definition level. Elements with definition levels 2 through 4 darkened should be answered as "yes/no" questions. Indicate definition level 1 for "yes" or definition level 5 for "no" to indicate if the elements either existed or did not exist within the project definition package at authorization.

Definition Levels:

1 - Complete definition
2 - Minor deficiencies
3 - Some deficiencies
4 - Major deficiencies
5 - Incomplete or poor definition
N/A - Not applicable

Note: If the project on which you are reporting is a building or infrastructure project, some of the following elements may not apply to your project. Please place a check in the "N/A" column to indicate "not applicable" if any element does not apply to your project.

	Definition Level at Authorization					
	Complete				Poor	
Technical Elements	1	2	3	4	5	N/A
Process Flow Sheets						
Site Location						
P&ID's						
Heat & Material Balances						
Environmental Assessment						
Utility Sources With Supply Conditions						

Mechanical Equipment List						
Specifications - Process/Mechanical						
Plot Plan						
Equipment Status						
Business Elements						
Products						
Capacities						
Technology						
Processes						
Site Characteristics Available vs. Req'rd						
Market Strategy						
Project Objectives Statement						
Project Strategy						
Project Design Criteria						
Reliability Philosophy						
Execution Approach Elements						
Identify Long Lead/Critical Equip. & Matl's						
Project Control Requirements						
Engineering/Construction Plan & Approach						

Design/Information Technology Practices

Please place a check to indicate the extent to which each design/information technology application listed below was used on this project. See the legend below for definition of the "Use Levels." If you believe that an application could not have been appropriately applied on this project check "NA."

Use Levels:

1 - Extensive Use	3 - Moderate Use	5 - No Use
2 - Much Use	4 - Little Use	N/A - Not applicable

40a. Was an ***integrated database*** utilized on this project? Yes __ No ____

If yes, please indicate the extent that each of the following shared data within the integrated database. If other applications were used, please list them. If no, proceed to question 40b.

	Use Levels					
	Extensive Use				No Use	
Applications	1	2	3	4	5	N/A
Facility planning						
Design / Engineering						
3D CAD model						
Procurement / Suppliers						
Material management						
Construction operations / Project controls						
Facility operations						
Administrative / Accounting						

40b. Was ***electronic data interchange (EDI)*** utilized on this project? Yes _____ No _____

If yes, please indicate the extent to which each of the following document types were transmitted using EDI. If other applications were used, please list them. If no, proceed to question 40c.

	Use Levels				
	Extensive Use			No Use	
Applications	1	2	3	4	5	N/A
Purchase orders						
Material releases						
Design specifications						
Inspection reports						
Fund transfers						

40c. Was ***3D CAD modeling*** utilized on this project? Yes ___ No ____

If yes, please indicate the extent to which a 3D CAD model was used for each of the following applications. If other applications were used, please list them. If no, proceed to question 40d.

	Use Levels					
	Extensive Use				No Use	
Applications	1	2	3	4	5	N/A
Define / communicate project scope						
Perform plant walk-throughs (Replacing plastic models)						
Perform plant operability / maintainability analyses						
Perform constructability reviews with design team						
Use as reference during project / coordination meetings						
Work breakdown and estimating						
Plan rigging or crane operations						
Check installation clearances / access						
Plan and sequence construction activities						
Construction simulation / visualization						

Survey control and construction layout						
Material management, tracking, scheduling						
Exchange information with vendors / fabricators						
Track construction progress						
Visualize project details or design changes						
Record "As-Built" conditions						
Train construction personnel						
Safety assessment / training						
Plan temporary structures (formwork, scaffolding, etc.)						
Operation / Maintenance training						
Turn-over design documents to the project owner						
Start-up planning						

40d. Was ***bar coding*** utilized on this project? Yes _____ No _____

If yes, please indicate the extent to which bar coding was used for each of the following applications. If other application were used, please list them. If no, proceed to question 41.

	Use Levels					
	Extensive Use				No Use	
Applications	1	2	3	4	5	N/A
Document control						
Materials management						
Equipment maintenance						
Small tool / consumable material control						
Payroll / Timekeeping						

Project Change Management Practices

Change Management focuses on recommendations concerning the management and control of both ***scope changes*** and ***project development changes***.

Yes No

41a. ___ ___ Was a formal documented change management process, familiar to the principal project participants used to actively manage changes on this project?

41b. ___ ___ Was a baseline project scope established early in the project and frozen with changes managed against this base?

41c. ___ ___ Were design "freezes" established and communicated once designs were complete?

41d. ___ ___ Were areas susceptible to change identified and evaluated for risk during review of the project design basis?

41e. ___ ___ Were changes on this project evaluated against the business drivers and success criteria for the project?

41f. ___ ___ Were all changes required to go through a formal change justification procedure?

41g. ___ ___ Was authorization for change mandatory before implementation?

41h. ___ ___ Was a system in place to ensure timely communication of change information to the proper disciplines and project participants?

41i. ___ ___ Did project personnel take proactive measures to promptly settle, authorize, and execute change orders on this project?

41j. ___ ___ Did the project contract address criteria for classifying change, personnel authorized to request and approve change, and the basis for adjusting the contract?

41k. ___ ___ Was a tolerance level for changes established and communicated to all project participants?

41l. ___ ___ Were all changes processed through one owner representative?

41m. ___ ___ At project close-out, was an evaluation made of changes and their impact on the project cost and schedule performance for future use as lessons learned?

41n. ___ ___ Was the project organized in a Work Breakdown Structure (WBS) format and quantities assigned to each WBS for control purposes prior to total project budget authorization?

The questionnaire is complete. Thank you for your participation.

Bibliography/References

Abu-Haijleh, Samer F., and Ibbs, William C.(1989). "Schedule Based Construction Incentives." *Journal of Construction Engineering and Management.* Vol. 115, no. 3. Sept. 1989. Pgs 430-443.

Ashley, David B., and Workman, B. Wayne (1986). *"Incentives in Construction Contracts." CII Source Document SD-8.* CII, Austin, TX.

Blank, Leland.(1980). Statistical Procedures for Engineering, Management, and Science. McGraw-Hill Book Company. New York.

CII Benchmarking and Metrics Data Report for 1997. CII, Austin, TX.

"Use of Incentives," CII Conference Implementation Packet 1995. CII, Austin, TX.

"Innovative Contractor Compensation Plans," CII Conference Packet (1996). Research Product. CII, Austin, TX.

"Cost-Trust Relationship," CII Publication 24-1 (1993). CII, Austin, TX.

DeGoff, Robert A., and Friedman, Howard A. (1985). Construction Management John Wiley and Sons. NY.

Hahn, Dewayne Edmon, and Borcherding, John David. (1997). "A Study of Superintendent and Management Views to Improve Construction Work Relationships." *A Report to the Dept. of Civil Engineering, University of Texas at Austin.* Austin, TX.

Hudson, D. N. 1997. *"Benchmarking Construction Project Execution."* University of Texas at Austin. Austin, TX.

Ibbs, C.W. and Abu Haijleh, Samer F. (1988). *"Unique features of Construction Contract Incentive Plans." CII Source Document SD-40.* CII, Austin, TX.

Ibbs, C.W. and Abu Haijleh, Samer F. (1988). "*Unique features of Construction Contract Incentive Plans.*" *CII Source Document SD-40.* CII, Austin, TX.

Jaafari, A. (1996). "Twinning Time and Cost in Incentive-Based Contracts." *Journal of Management in Engineering.* Vol. 12, No. 4. Pgs 62-72.

Jaraiedi, Majid, Plummer, Ralph W., and Aber, Mary S. "Incentive/Disincentive Guidelines for Highway Construction Contracts." Journal of Construction Engineering and Management. Vol. 121, No.1. March 1995. Pgs 112-120.

Mendelsohn, Roy. (1984). "Early Completion Schedules: The Promises and Pitfalls." *Journal of Management in Engineering.* Pgs 28-30.

Neil, James M. (1991). "Incentives-Powerful Tools for Owners." *Cost Engineering.* Vol. 33. No. 1. Pgs 19-23.

Stukhart, George M. (1984) "Contractual Incentives." *Journal of Construction Engineering and Management.* Vol 110. No. 1. Pgs 34-41.

"The Quality Journey: A TQM Roadmap for Public Transportation," Transit Cooperative Research Program-TCRP Report 8 (1995). National Academy Press. Washington. D.C.

Vita

Jayson Doliber Mitchell was born in Salem, Massachusetts on September 25th, 1970. He is the son of Diane Jessica Mitchell and Clark Allen Mitchell. After graduating from Beverly High School, Beverly, Massachusetts, he attended Tufts University in Medford, Massachusetts. He received his Bachelor of Science Degree in Civil Engineering and commission as an Ensign in the Civil Engineer Corps in May 1992. During the following years he served as both a Company Commander and a Detachment Officer in Charge with Naval Mobile Construction Battalion FORTY and as a Project Engineer for the Resident Officer in Charge of Construction in Pensacola, Florida. In August 1997, he entered the Civil Engineering Graduate School at the University of Texas where he studied Construction Engineering and Project Management.

Permanent address: 6 Hancock Street
Beverly, MA, 01915

This thesis was typed by the author.

20 51NPS 1663 ICI
1/99 22527-157

DUDLEY KNOX LIBRARY
NAVAL POSTGRADUATE SCHOOL
MONTE[illegible]3943-5101

DUDLEY KNOX LIBRARY
3 2768 00360115 4